Recent Changes in Patterns of Productivity Growth in Canada

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RECENT CHANGES IN PATTERNS OF PRODUCTIVITY GROWTH IN CANADA

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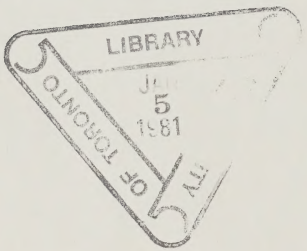

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PREFACE

Since 1973, labour productivity in Canada has grown at a much slower average rate than it did over much of the postwar period. Part of the post-1973 slowdown in productivity growth is related to the cyclical performance of the economy over this period. The extent of the slowdown appears to have been larger than can be accounted for by cyclical factors alone, however, and has led to the suggestion that the trend growth rate of productivity in Canada has declined in the 1970s.

This paper reviews a number of factors which have been cited as being possible contributors to a decline in the trend rate of productivity growth since 1973. Two factors - a very sharp decline in productivity in Canada's oil- and natural gas-related industries, and a slowdown in the rate of growth of the capital intensity of production in most industrial sectors - are identified as having significantly lowered the trend rate of productivity growth in the 1970s. It cannot be assumed, however, that these factors will continue to operate to depress productivity growth, at least not to the same extent. With respect to the impact of environmental-protection regulations, available data do not allow conclusions to be drawn as to whether the installation of pollution-abatement equipment has significantly affected Canada's aggregate productivity performance. Other factors examined in the paper cannot be identified as having contributed to the post-1973 slowdown in productivity growth. These factors include: changes in the demographic composition of employment; increases in the share of employment accounted for by services-producing industries; and declines in average hours worked per employed person.

This paper was prepared in the Long Range and Structural Analysis Division under the general direction of Scott Clark, Director of the Division. The paper has benefitted substantially from the comments of other members of the Department of Finance, as well as from discussions with persons at Statistics Canada, the Bank of Canada, the Economic Council of Canada, Informetrica Ltd., the C.D. Howe Research Institute, and members of the Economics Department of the University of Toronto. Professor Paul Davenport of McGill University has made particularly important contributions to the paper. The responsibility for the views expressed in the paper, however, rests entirely with the authors.

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1. INTRODUCTION

From the end of World War II until the early 1970s, the Canadian economy experienced a high average rate of growth. Real gross national expenditure (GNE) grew at an average annual rate of 5.1 per cent from 1948 to 1973.(1) More than half of this aggregate output growth was attributable to the growth of aggregate output per person; aggregate labour productivity (defined as GNE per employed person) grew at an average annual rate of 2.7 per cent per year over this period.(2) GNE per capita more than doubled over the 26-year period, growing at an average annual rate of 3.0 per cent per year. About 90 per cent of this real per capita output growth was in turn accounted for by the 2.7-per-cent average annual growth of aggregate labour productivity.(3)

The share of per capita GNE growth accounted for by labour productivity growth varied somewhat between the early postwar years and the early 1970s. Over each of the main periods of cyclical activity, however, productivity growth remained the dominant source of per capita output growth.(4)

Since 1973, however, rates of growth of productivity and output in Canada have been much lower than they were during the previous two and a half decades. From 1974 to 1979, GNE growth averaged 3.1 per cent

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(1) This is a compound growth rate calculated using 1947 as the base year. In all cases where average growth rates referring to more than one year are provided in the paper, they are compound growth rates calculated using the year prior to the defined period as the base year.
(2) GNE per employed worker is widely used as a measure of economy-wide labour productivity. It is not, however, an official Statistics Canada productivity measure. Section 2.2 of Chapter 2 below reviews the important difference in the recent movements of GNE per employed worker and an aggregate productivity index based on real domestic product (RDP).
(3) The growth in real per capita output can be considered to be the sum of the growth rates of four underlying components: aggregate labour productivity; the share which the labour force source population comprises of the total population; the participation rate; and the employment rate (the proportion of the labour force which is employed). Between 1947 and 1973, changes in the source population share, the participation rate and the employment rate together accounted for about 10 per cent of aggregate real per capita output growth. Real per capita income growth depends upon both growth in real per capita output and movements in the terms of trade.
(4) For example, aggregate labour productivity grew by 2.2 per cent annually on average from 1957 to 1973, while real per capita output grew at a 3.0-per-cent average annual rate. Changes in participation rates and the share of the total population accounted for by the working age population were much more important contributors to real per capita output growth from 1957 to 1973 than they were from 1948 to 1956.

per year. Real GNE per capita grew at an average annual rate of 1.9 per cent, while productivity growth averaged only 0.3 per cent per year.(1) During this six-year period, aggregate labour productivity recorded increases only in 1976, 1977, and 1978. GNE per person employed fell in each of 1974, 1975, and 1979.

Part of the fall-off in the post-1973 average rate of productivity growth appears to be attributable to the relatively weak aggregate growth experienced since 1973. In periods of economic expansion, labour is employed intensively, and productivity rises strongly, at least in the initial stages of the expansion. A period of slow growth, on the other hand, tends to see a more marked slowing of output growth than of employment growth. Particularly in the initial stages of a slowdown, managers tend to maintain the size of their work forces. Even if output must be cut back, it is often cheaper to retain employees, particularly the most skilled and experienced workers, rather than dismiss them and then have to bear substantial hiring and training costs when demand picks up again. Consequently, productivity tends to grow only slowly during slow growth periods, and may even decline.

Table 1 compares rates of growth of GNE and labour productivity in the commercial non-agricultural sector in Canada over the period 1947-1978.(2) Over cyclically comparable periods, a relatively high degree of stability in average rates of productivity growth has been recorded. For example, 1956, 1966 and 1973 were all years of peak cyclical activity. Productivity in the commercial non-agricultural sector grew at an average rate of 2.5 per cent per year from 1957 to 1966, and by 3.1 per cent per year from 1967 to 1973. The year-to-year cyclical movements in productivity growth, however, appear to have been pronounced. Years of low GNE growth have tended to be associated with below-average productivity growth, while strong growth in productivity has tended to accompany rapid GNE growth.

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(1) Strong increases in labour force participation, and a major increase in the source population share of the total population, were more important contributors to growth in real output per capita than was productivity growth in the 1974-1979 period.

(2) Almost no meaningful productivity estimates are available for most of the non-commercial sector of the economy. In addition, productivity growth in the agricultural sector of the economy between any two years is much more sensitive to the size of the harvests in those years than to the business cycle. The productivity measure for the commercial non-agricultural sector thus probably gives the best indication of the degree to which labour productivity is cyclically sensitive.

Table 1

Annual Percentage Increases in GNE and Labour Productivity in the Commercial Non-Agricultural Sector, Canada, 1947-1978(1)

	Annual Percentage Increases	
	GNE	Labour Productivity, Commercial Non-Agricultural Sector
1947	4.3	0.2
1948	2.5	0.2
1949	3.8	1.8
1950	7.6	5.2
1951	5.0	1.1
1952	8.9	2.9
1953	5.1	4.2
1954	-1.2	2.5
1955	9.4	6.6
1956	8.4	3.4
1957	2.4	-0.6
1958	2.3	3.4
1959	3.8	3.6
1960	2.9	2.0
1961	2.8	3.2
1962	6.8	3.1
1963	5.2	2.5
1964	6.7	3.5
1965	6.7	2.3
1966	6.9	1.8
1967	3.3	2.2
1968	5.8	5.3
1969	5.3	2.5
1970	2.5	1.8
1971	6.9	4.1
1972	6.1	2.8
1973	7.5	3.0
1974	3.6	0.1
1975	1.2	-1.0
1976	5.4	4.2
1977	2.4	0.8
1978	3.4	1.9

(1) GNE estimates are available for 1979. However, official estimates of labour productivity in 1979 have not yet been published by Statistics Canada.

Source: Statistics Canada, National Income and Expenditure Accounts, Cat. 13-201, and Aggregate Productivity Measures 1946-1978, Cat. 14-201.

A similar relationship between GNE and productivity growth is evident in the data for the period 1974-1978. Strong GNE growth in the post-1973 period occurred only in 1976; this growth was associated with very strong productivity growth. Slow growth in GNE and slower or negative growth in productivity characterized the remaining years of the period.(1)

The patterns of productivity growth outlined in Table 1 suggest that part of the post-1973 reduction in the average rate of productivity growth in Canada is attributable to the relatively weak cyclical performance of the economy over an important part of this period. It also appears as though the extent of the post-1973 slowdown in productivity growth has been larger than can be explained in terms of cyclical factors alone, however. The only postwar period during which growth rates comparable to those of the 1974-1978 period were recorded were the years 1957-1961, during which GNE growth and commercial non-agricultural sector productivity growth averaged 2.8 and 2.3 per cent per year, respectively. Over the years 1974-1978, however, GNE growth has averaged 3.2 per cent per year, while the average annual growth rate of commercial non-agricultural sector productivity has fallen to 1.2 per cent. These considerations have led to the suggestion that structural changes have taken place in the economy, and that the effect of these changes has been to depress productivity growth to rates lower than would be accounted for by the slow growth of the economy.

The purpose of this paper is to address the issue of whether productivity-reducing structural change has occurred in Canada since 1973. The paper will review a number of factors which have been cited as possible contributors to a slowdown in the trend rate of productivity growth, and attempt to assess which if any of these factors could have contributed significantly to the post-1973 slowdown in productivity growth.

The paper has three more chapters. Chapter 2 examines a number of the important problems involved in defining and measuring productivity in Canada. It reviews the differences which have appeared since 1973 in the rates of growth of two measures of aggregate Canadian labour productivity - GNE per employed worker and real domestic product (RDP) per employee. The conclusion of this analysis is that these differences cannot be explained in a satisfactory manner, and therefore that the precise extent of the aggregate productivity slowdown which has occurred since 1973 is uncertain. Some major limitations of the official productivity statistics are then examined; these limitations affect both the nature of the empirical analysis of productivity movements which can usefully be undertaken, and the conclusions which can be drawn from empirical work.

Chapter 3 begins by reviewing the major patterns of productivity growth by industry over the postwar period. A series of factors which have been suggested as possible contributors to the post-1973 productivity slowdown are examined. Evidence presented in the chapter suggests that

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(1) Appendix 1 reviews quarterly changes in output, employment and productivity since the beginning of 1973. This provides a further perspective on the degree of cyclicality in productivity movements in Canada in recent years.

reductions in the growth rate of capital intensity in a number of industries, and sharp declines in productivity in the oil and natural gas industry since 1973, have operated to depress productivity growth since the early 1970s. With respect to the impact of government environmental-protection regulations requiring the installation of pollution-abatement equipment, the available data do not permit conclusions to be drawn. Finally, a number of other factors examined in the chapter cannot be identified as having contributed significantly to the decline in the rate of productivity growth. These factors include: the increased share of women and young persons in employment; increases in the share of employment accounted for by the service sector; and changes in the post-1973 rate of growth of average hours worked per employee.

Chapter 4 summarizes the main conclusions of the paper. As was noted above, it appears as though the abrupt reversal in 1973 of the trend of productivity growth in Canada's oil and natural gas industry played a major role in the overall recorded post-1973 productivity decline. It seems likely that future production of oil and natural gas will on average grow more slowly than in the period 1961-1973; coupled with the use of more labour-intensive production techniques in the production of synthetics, and the need to use more capital and labour in the development of frontier supplies, this will imply that productivity growth in this industry comparable to that recorded in the 1960s and early 1970s will not resume. In the absence of improvements in productivity growth in other sectors, this implies that the future trend rate of aggregate productivity growth will be somewhat lower than that recorded from the mid-1950s to the early 1970s. As far as capital-labour ratios are concerned, it is difficult to say whether their growth rates will continue to decline, or will grow more quickly in the future. In part, this is because it is difficult to isolate the effects on capital-labour growth rates of different factors, including the major increase in energy prices after 1973. Because of the uncertainties surrounding this issue, it cannot be assumed that capital-labour growth rates have been permanently lowered. In turn, this would suggest that the underlying rate of productivity growth need not have been lowered permanently as a result of the decline in the trend rate of growth of capital intensity in the 1970s.

The approach taken in the paper has been to focus on identifying structural influences on productivity growth and estimating their effects. The estimates of the impacts of changing capital intensity growth and the changing supply situation in the oil and natural gas industry provided in this paper account for part, but by no means all, of the post-1973 productivity slowdown. Some portion of that part of the slowdown not accounted for by the structural factors identified here may reflect the influence of other structural factors. Some part also represents the impact of cyclical influences on productivity growth. However, because of the remaining uncertainties, and also because of the measurement problems which are discussed in the paper, it is not possible to calculate the size of the impact of cyclical influences on productivity growth since 1973.

To the extent that potential productivity growth has been permanently reduced by structural changes which have occurred since 1973, the future rate of growth of Canadian per capita income may have been

lowered. Such a development could have a number of important implications. For example, a reduction in the trend rate of productivity growth could exacerbate inflationary pressures in the economy, directly through its impact on unit labour costs, and indirectly as well, through increased competition for shares of an aggregate real income which could grow only at a slower rate than had obtained in the past. Attempts to fulfill expectations given these changed circumstances could heighten inflationary pressures in the economy. Another type of implication relates to the adjustments which will be required as Canadian energy prices are increased more rapidly in the future. It will be easier to make the income transfers which this process of adjustment demands if real incomes are growing strongly, rather than remaining constant or growing only slowly.

2. CANADIAN PRODUCTIVITY DATA: ISSUES AND PROBLEMS

The focus of the empirical analysis presented in Chapter 3 is upon productivity growth patterns in individual industries. This reflects a theme which runs throughout the paper, i.e., that very little meaningful analysis of aggregate productivity trends in the economy is possible, because of the severe limitations imposed by the quality of the existing data. Efforts to identify structural changes which have affected productivity growth must be focussed on industries for which data are of a sufficient quality to support empirical analysis.

The purpose of this chapter is to review Canadian productivity data, and some major problems associated with them. This review is essential to the subsequent empirical analysis. The first section of the chapter explains briefly why the analysis is limited to an examination of labour productivity data. Section 2.2 then examines the sharp differences in the rates of growth of GNE-based and RDP-based measures of aggregate productivity growth in Canada which have been recorded since 1973. These differences cannot be satisfactorily reconciled; this implies that the degree to which aggregate productivity growth has declined since 1973 remains somewhat uncertain. Finally, Section 2.3 discusses the main problems associated with Statistics Canada RDP-based labour productivity estimates, and provides a judgement as to the degree of confidence which can be attached to these estimates on an industry-by-industry basis. This section also reviews the revisions which have been made to official productivity estimates in recent years.

It is important to stress at the outset that the following analysis of the weaknesses in Canadian productivity statistics is not intended as a criticism of Statistics Canada's methodologies in this area, nor should it be interpreted as such. Statistical agencies in all industrialized countries are faced with similar major conceptual and data problems in trying to measure output and productivity in a number of important industries and sectors. The sole purpose of the discussion which follows is to provide background information which is essential to the subsequent analysis.

2.1 The Choice of Productivity Concepts

Productivity is defined in general terms as the ratio of a measure of output to one or more of the factor inputs required to produce that output. Within this general definition, however, many different productivity measures may be distinguished. A measure of marginal factor productivity, for example, would relate incremental output to the incremental units of input(s) associated with that output. Average factor productivity, on the other hand, describes the ratio of total output to all units of input(s) used to produce that output. Productivity measures also vary according to the input(s) specified in their calculation. Labour productivity measures, which relate output to some

measure of labour input, are the most common form of productivity measures used in empirical analysis. However, estimates of capital productivity (output per unit of capital services) may be constructed if capital stock data are available and if certain assumptions are made in order to convert capital stock estimates into measures of capital services actually used in producing output. Estimates of primary factor productivity (output per unit of labour and capital combined) may also be computed; this requires, however, that estimates of labour input and capital services be converted to common units of measurement.

For a number of reasons, the focus of this study is on the behaviour of average labour productivity as measured by output per person employed.(1) First, the growth in labour productivity is a major factor contributing to the growth in per capita income. Second, the post-1973 productivity slowdown has been identified in terms of a change in the patterns of growth of average labour productivity. This dictated that these patterns be reviewed first, even if other measures of productivity might be examined later. Third, estimates of average labour productivity are the only productivity measures which are released by Statistics Canada. The agency states that while "... ideally, all resources should be counted as inputs ..., at the present stage of development, only labour inputs can be measured."(2) Fourth, the detailed assessment of the official productivity statistics carried out as part of this study(3) indicates that there are a number of serious weaknesses in these data which severely limit the types of analysis which can usefully be carried out with them. This suggests that capital productivity or primary factor productivity estimates, the preparation of which would have required more and stronger assumptions than are required in the estimation of labour productivity, might well be of too limited a degree of statistical reliability to support conclusions based upon an analysis of their movements over time.

2.2 Differences in Movements of RDP- and GNE-based Aggregate Productivity Measures

Economy-wide estimates of labour productivity are subject to a considerable degree of error, in the first instance because of the problems associated with the measurement of output in the non-commercial sector. The output of the sector is for the most part measured in terms of labour input, which makes productivity estimates for this sector meaningless. Statistics Canada believes that, since roughly 20 per cent of RDP is accounted for by the non-commercial sector, economy-wide measures of aggregate productivity are of a doubtful enough quality that they should not be published.

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(1) The focus upon estimates of output per employed person rather than output per man-hour reflects the judgement of the authors that employment estimates by industry are probably more reliable than corresponding estimates of man-hours worked.
(2) Statistics Canada, Aggregate Productivity Measures 1946-1978, Cat. 14-201, p. 17. This statement should probably be interpreted as a judgement that labour inputs are the only factor inputs which can be measured accurately enough at the present time to be used in the preparation of reliable productivity estimates.
(3) See Sections 2.2 and 2.3 below.

This problem with aggregate productivity measures notwithstanding, there is wide interest in such measures, which are used in both the analysis of present economic circumstances and the projection of future developments. Two such measures can be calculated for Canada. The first defines productivity as real GNE divided by the labour force survey estimate of employment.(1) GNE per employed person is the most widely used estimate of productivity movements in the economy at large. A second aggregate measure is RDP per employed person, with employment being measured largely on an establishment basis. This measure of employment can be obtained from Statistics Canada.

Table 2 provides estimated rates of growth of these two measures of aggregate productivity, and the underlying output and employment components, for selected periods. The periods covered include the cyclically-neutral periods 1957-1966 and 1967-1973, as well as the early postwar years 1947-1956, against which the growth rates for the post-1973 period can be compared.(2) Data are also provided for the slow growth period 1957-1961.

Table 2

Average Annual Percentage Increases in RDP- and GNE-based Aggregate Productivity Measures and their Components, Canada, Selected Periods

	1947-1956(1)	1957-1966	1967-1973	1974-1978	1957-1961
RDP	5.4	4.5	5.2	3.6	2.3
Employment (establishment survey-based)	1.8	2.2	2.6	2.5	1.1
RDP/employed person	3.6	2.2	2.6	1.1	1.2
GNE	5.3	4.6	5.4	3.2	2.8
Employment (labour force survey-based)	1.8	2.5	2.8	2.6	1.6
GNE/employed person	3.5	2.1	2.5	0.5	1.2

(1) In all cases where average growth rates referring to more than one year are provided in the paper, they are compound growth rates calculated using the year prior to the defined period as the base year. Thus, for example, average annual growth rates for the 1947-1956 period are 10-year average growth rates, calculated using 1946 as the base year, and 1956 as the end year.

Source: Calculated from data obtained from the Input-Output Division of Statistics Canada, and Statistics Canada, National Income and Expenditure Accounts, Cat. 13-201, The Labour Force, Cat. 71-001, and Real Domestic Product by Industry, Cat. 61-213.

(1) This household survey-based employment estimate is the only measure of economy-wide employment published by Statistics Canada on a regular and timely basis.

(2) In Table 2, and in most of the rest of the paper, the post-1973 period is defined as the years 1974 through 1978 inclusive. The analysis covers only the period to 1978, because official productivity estimates for 1979 are not currently available.

For all of the periods for which data are provided in Table 2, except for 1974-1978, the economy-wide aggregate productivity measures moved very closely together. During these periods, the growth rates of the two measures were separated at most by one-tenth of a percentage point. In the 1974-1978 period, however, the RDP-based measure grew by 1.1 per cent per year, while the growth rate of the GNE-based measure was only 0.5 per cent per year. This differential in growth rates raises questions as to the extent to which productivity growth has fallen since the early 1970s. On an RDP basis, productivity growth is currently estimated to have fallen, on average, by 1.5 percentage points per year between the periods 1967-1973 and 1974-1978 (i.e., from 2.6 to 1.1 per cent per year). On a GNE basis, the corresponding decline is estimated to have been a full 2.0 points (i.e., from 2.5 to 0.5 per cent per year).

The relationship over time between the employment and the output components of the two productivity measures has been somewhat more volatile. In the period 1957-1961, measured real GNE growth was much higher than RDP growth, averaging 2.8 per cent per year versus the 2.3-per-cent average annual growth recorded by RDP. However, labour force survey-based employment grew by 1.6 per cent per year, versus the only 1.1-per-cent average annual growth rate of employment estimated on an establishment basis. The identical productivity-growth estimates on the two bases over the 1957-1961 period thus masked very wide differences in the measured growth rates of output and employment during these years. In turn, this suggests that the 1974-1978 experience of differential productivity movements may not be as unique, in a fundamental sense, as first appears; the two sets of output and employment growth patterns have diverged before, with, however, offsetting impacts on productivity growth.(1)

The differences which have appeared from time to time in the relationship between establishment-based and labour force survey-based estimates of employment have been studied by Statistics Canada, and by other researchers. Although there are many differences in the two approaches to the measurement of employment (in sampling techniques, reference period, definition of employment, etc.), it is not easy to determine why the household-survey-based estimate should have consistently grown more quickly than the establishment-based measure since the mid-1950s (see Table 2). However, the extent to which the measures diverge appears to have been narrowing over time. In the period 1974-1978, the differential in employment growth rates accounted for only a minor portion of the difference between the RDP- and GNE-based productivity growth rate differentials. In this period, a substantially stronger average annual rate of growth of RDP than GNE (3.6 versus 3.2 per cent per year) accounted for the bulk of the difference in the productivity growth rates.

To assess why GNE and RDP growth rates have diverged widely since 1973, it is useful to review the differences between their current dollar counterparts - gross national income (GNP) and gross domestic product at factor cost (GDP). There are two major conceptual differences

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(1) Patterns similar to those of the 1957-1961 period also developed in 1967-1973. The differences between the two sets of output and employment growth rates were not nearly as pronounced, however.

between GNP and GDP. A domestic measure of Canadian output or income includes income generated in this country, but accruing to foreigners; a national income measure excludes such income. GDP is thus calculated inclusive of net interest and dividend payments made to foreigners by Canadians; GNP excludes these payments. In addition, GDP is domestic product valued at factor cost, while GNP is equal to national product valued at market prices. The difference between a market price and factor cost valuation of output is indirect taxes less subsidies.

Table 3 gives an example of how current dollar estimates of GNP and GDP are related. For 1978, net interest and dividend payments abroad of over $5.6 billion are added back to GNP to arrive at estimated GDP at market prices in that year of $236 billion. The subtraction from GDP at market prices of indirect taxes less subsidies equal to $25.4 billion yields estimated GDP at factor cost. In addition, the residual error generated in the estimation of GNE and GNP must be eliminated; conceptually, the adjustments described in Table 3 relate GDP at factor cost to GNP at market prices, exclusive of the residual error of estimate.(1)

Table 3

Relation Between Gross National Product at Market Prices and Gross Domestic Product at Factor Cost, Canada, 1978

	$ millions
GNP at market prices:	$230,407
Add: Net interest and dividend payments abroad:	5,620
Equals: GDP at market prices:	236,027
Subtract: Indirect taxes less subsidies:	- 25,423
Residual error of estimate:	- 412
Equals: GDP at factor cost:	210,192

Source: Statistics Canada, National Income and Expenditure Accounts, Cat. 13-201.

The calculations set out in Table 3 show that the conceptual differences between GNP and GDP, as well as the adjustment for the residual error, always fully explain the differences between these two aggregates, since GDP is estimated by making the various adjustments to GNP. However, the situation is not the same in the case of the relationship between real GNE (GNP) and RDP. Independent estimates of real GNE and RDP are prepared by Statistics Canada, and involve the use to some

(1) For further information on these relationships, see the National Income and Expenditure Accounts, Volume 3, Cat. 13-549, Chapters 9, 10 and 12.

extent of different methodologies and different types and sources of data. Thus there are two main reasons why estimates of RDP and GNE can diverge: conceptual differences between the two measures, and "statistical errors and discrepancies reflecting the use of different source material".(1)

A reconciliation of GNE and RDP estimates has been attempted, in order to assess whether conceptual differences or statistical errors and discrepancies account for the bulk of the difference in the behaviour of the two aggregate output measures. The results of this reconciliation exercise are presented in Table 4. Data are presented for individual years from 1962 to 1978 and for selected sub-periods within the 1960s and 1970s, although much of the following discussion is limited to the post-1973 years. Columns 1 and 4 of Table 4 provide percentage growth rates of GNE and RDP, respectively. Column 2 provides growth rates of GNE adjusted through the adding back of estimated real net investment income payments to foreigners, while column 3 gives corresponding growth rates of GNE adjusted further through the subtraction of the residual error and of estimated real indirect taxes less subsidies. Conceptually, growth rates provided in column 3 should be RDP growth rates. However, these are not rates of growth of RDP as estimated by Statistics Canada, but growth rates of an RDP measure which is calculated by making the same adjustments to GNE in real terms as are made in Table 3 to derive GDP from current dollar GNP.

Of the three adjustments which are made here to GNE in order to generate calculated RDP of column 3, the adjustment for net investment income payments to foreigners should clearly operate towards reducing growth rate differentials between GNE and RDP. Indeed, to the extent that adjustments to eliminate the residual error tended to have no net impact on the estimates over a period of several years, the adjustment for net investment income payments should completely account for the GNE-RDP growth rate differences. This is because real indirect taxes less subsidies create a difference between the levels of RDP and GNE, but should not lead to differences in their rates of growth.(2)

The comparison of columns 1 and 2 show, however, that only 0.1 percentage point of the 0.4-percentage-point differential between GNE and RDP growth rates over the period 1974-1978 can be attributed to the adjustment for net investment income payments abroad. Over this period, real GNE growth averaged 3.2 per cent annually, while GNE adjusted for net investment income payments abroad grew by 3.3 per cent. For two of the five years of this period (1977 and 1978), the adjustment narrows the GNE-RDP growth rate differential, as it would be expected to. For two other years (1974 and 1976), however, the adjustment widens the growth rate differential, while it has no effect on the 1975 differential.

(1) Statistics Canada, National Income and Expenditure Accounts, Volume 3, Cat. 13-549, p. 266.

(2) Constant dollar indirect taxes less subsidies are calculated as the base year tax or subsidy rate times the volume of output. Since the tax rate is held constant at its 1971 level, changes in the level of real indirect taxes less subsidies do not lead to differences in rates of growth of RDP and GNE.

Table 4

Annual and Average Annual Percentage Growth Rates of GNE, GNE Adjusted for Differences Between GNE and RDP, and RDP, Canada, 1962-1978

		GNE Adjusted for:		
	GNE (1)	Net Investment Income Paid to Foreigners (2)	Net Investment Income Paid to Foreigners, Residual Error and Indirect Taxes less Subsidies (3)	RDP (4)
1962	6.8	6.7	7.6	7.1
1963	5.2	5.2	5.4	5.5
1964	6.7	6.7	6.6	6.8
1965	6.7	6.7	6.2	7.4
1966	6.9	6.9	7.0	6.7
1967	3.3	3.4	3.5	3.5
1968	5.8	5.7	6.1	5.6
1969	5.3	5.2	5.7	6.1
1970	2.5	2.6	1.7	2.4
1971	6.9	7.0	6.5	5.9
1972	6.1	5.9	6.5	5.5
1973	7.5	7.4	7.5	7.7
1974	3.6	3.4	3.3	4.7
1975	1.2	1.2	0.8	0.7
1976	5.4	5.7	5.4	5.3
1977	2.4	2.8	N/A(1)	3.2
1978	3.4	3.7	N/A	4.0
Average Annual Rates of Growth				
1962-1966	6.5	6.4	6.6	6.7
1967-1973	5.4	5.3	5.3	5.2
1974-1976	3.4	3.4	3.1	3.5
1974-1978	3.2	3.3	N/A	3.6

(1) Constant dollar estimates of real indirect taxes less subsidies are available only for the years 1961-1976 inclusive.

Source: Statistics Canada, Real Domestic Product by Industry, Cat. 61-213, National Income and Expenditure Accounts, Cat. 13-201, The Input-Output Structure of the Canadian Economy in Constant Prices, 1961-1974, Cat. 15-509, and additional information provided by the Input-Output Division and the Gross National Product Division of Statistics Canada; and the Long Range and Structural Analysis Division, Department of Finance.

The fact that the adjustment for net investment income payments to foreigners explains only a relatively small part of the post-1973 GNE-RDP differential in growth rates, and in some years widens the estimated differential, indicates that statistical errors and discrepancies are probably the major factor underlying this differential.(1) A comparison of the growth rates of calculated RDP, column 3, and official estimates of GNE and RDP, columns 1 and 4, confirm this. For the two sub-periods prior to 1974, it appears as though the adjustment for the conceptual differences between GNE and RDP removes half of the difference between average annual rates of growth of GNE and RDP. However, in a number of individual years, the growth rates of calculated RDP diverge very markedly from the growth rates of official estimates of RDP. In addition, in eight of the 12 individual years prior to 1974 for which data are presented, the reconciliation adjustments result in a widening of the GNE-RDP growth rate differential.

With respect to the 1974-1976 period, the adjustments for conceptual differences largely eliminate the important growth rate differential for 1975. For 1974, however, the adjustment widens even further, though by a small amount, the very large differential between GNE and RDP growth rates. Over the three years 1974-1976, the average impact of the reconciliation adjustments is to widen the GNE-RDP growth rate differential.

In summary, the analysis of this section leads to the unsatisfying conclusion that it is not possible to identify why RDP and GNE growth rates have diverged since 1973, and thus why RDP- and GNE-based productivity estimates provide a significantly different reading on the extent to which productivity growth has slowed since 1973.

2.3 Problems Associated with the Measurement of Output and Productivity in Canada(2)

Because of both conceptual and measurement problems, only estimates of average labour productivity are published by Statistics Canada. These estimates appear in the annual publication, Aggregate Productivity Measures. They are presented only in index form, in order to emphasize

(1) The rather arbitrary way in which nominal investment income payments to and receipts from foreigners are deflated may itself be a source of statistical error. Statistics Canada notes that:

> the deflation of the components of exports and imports of services (invisibles) presents a variety of problems because there are no satisfactory ways of deflating income-type components. Interest and dividend payments are deflated with the implicit price index of merchandise exports, while interest and dividend receipts are deflated with the implicit price index of merchandise imports.

(Statistics Canada, National Income and Expenditure Accounts, Volume 3, op. cit., p. 286.)

(2) This section is based upon the paper, Productivity Measurement by Statistics Canada, Long Range and Structural Analysis Division, Department of Finance, mimeo., May 1979. This paper benefitted greatly from the encouragement and advice of officials at Statistics Canada; without their close cooperation, its preparation would not have been possible.

the importance of their being viewed as measures of trends rather than of absolute levels, and are calculated as the ratio of two other indexes: an index of real domestic product (RDP) and a labour input index.

The only major industry groups for which separate productivity indexes are published are agriculture and manufacturing; the remaining published productivity indexes cover various groups of industries within the commercial sector of the economy.(1) Productivity indexes are not published at a more disaggregated level for two reasons. First, there are serious problems involved in accurately classifying and matching output and labour input by industry or industry group. Misclassification may occur even at the level of broad industry categories, for example between trade and manufacturing. These problems are not likely to be serious at the level of disaggregation at which data are published. Second, the quality of output and labour input measures varies widely across industries. While meaningful productivity measures are available for some disaggregated industries or industry groupings, the publication of such indexes for all major industries within the commercial sector could create an unwarranted appearance of consistent quality.

These problems and concerns notwithstanding, it is possible to obtain from Statistics Canada a more disaggregated set of productivity indexes than that published. Indeed, separately-published RDP indexes and measures of labour input can be combined to create productivity indexes at a fine level of industrial detail. The attractiveness of more disaggregated productivity indexes is that they permit a more detailed analysis of productivity change than is possible using published data. The major danger in using more disaggregated productivity estimates is that the quality of these estimates may not be adequate to support much empirical analysis.

It is thus important to undertake an assessment of the quality of disaggregated RDP and labour input measures underlying the Statistics Canada productivity indexes, before proceeding with the analysis of productivity behaviour. The following discussion focusses upon the uneven quality of industrial measures of output, since this appears to be the major barrier to the calculation of reliable and consistent productivity measures at the industry level.

Table 5 outlines the type of measures underlying the RDP indexes for industries in the goods-producing sector of the economy, and provides a judgement as to the quality of the output measures in each industry. The table also provides the share of economy-wide RDP which each industry accounted for in 1971.

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(1) Groupings of industries for which productivity indexes are published include: all commercial goods-producing industries; commercial non-agricultural goods-producing industries; commercial goods-producing industries excluding agriculture and manufacturing; commercial services-producing industries; commercial non-agricultural industries, and all commercial industries.

Table 5

Overview of the Nature and Quality of Annual RDP Measures, Goods-Producing Industries, Canada

Industry	Main Type of Output Measure	Quality of Measure(1)	1971 Percentage Share of Total RDP
Agriculture	value added	good	3.4
Forestry	gross output	poor	0.8
Fishing and trapping	gross output	good	0.2
Mines, quarries and oil wells	gross output	good	3.8
Manufacturing	value added	good	22.8
Construction	gross output	fair	7.0
Electric power	gross output	good	2.1
Gas	gross output	good	0.4
Water systems and other utilities	gross output	poor	0.2
All goods-producing industries			40.6(2)

(1) The judgements of both the authors of this paper and Statistics Canada officials are reflected in the quality assessments provided in this table.
(2) Shares do not sum to the sector total because of rounding.

Source: Statistics Canada, Real Domestic Product by Industry, 1971-1977, Cat. 61-213, Aggregate Productivity Measures, 1946-1977, Cat. 14-201, and unpublished information.

Output measurement is described in Table 5 as being good, fair or poor in quality, depending upon the characteristics of each of the measures. Good RDP measures are those with which no major conceptual or data problems are associated, and which can be used in calculating reliable estimates of productivity trends. Fair RDP measures exist in some industries in which there are significant conceptual or data barriers to the accurate measurement of outputs, but for which the output measures are judged to provide a not unreasonable indication of output movement. Finally, in some industries output is measured in such a way that no meaningful productivity estimate can be made. Such output estimates are described as being poor in quality.

Where possible, Statistics Canada calculates RDP indexes by deflating both the value of output and the cost of intermediate inputs in order to arrive at measures of net output, or value added. Such measures are generally judged to be of good quality. In most years, however, data limitations prevent the calculation of net output measures for all goods-producing industries except agriculture and manufacturing. Even in these industries, a substantial amount of time may be required for

the information on which net output calculations are based to become available. Other measures must be used in the interim as proxies for net output. In most other goods-producing industries, gross output measures are used as proxies for net output in most years. The quality of such measures varies somewhat, but is often high. In the mining industry, for example, the quantities of mineral products produced are judged to accurately reflect trends in net output. For forestry, however, the gross output measure, which is based on the estimated production of main products in the logging industry, is felt to be a poor proxy for changes in net output.

The goods-producing sector as a whole accounted for 40.6 per cent of RDP in 1971. Of this share, some 32.6 points, or slightly over 80 per cent, was made up of industries in which output measures were judged to be good in quality. There are major problems involved in the estimation of the output of a large part of the non-residential construction industry; for this reason, the quality of the overall construction output measure is felt to be fair. Within the goods-producing sector, only the estimates for forestry, and water systems and other utilities, are felt to be poor in quality.

Table 6 provides comparable information relating to the output measures for services-producing industries in Canada. As in the case of goods-producing industries, there are a limited number of services-producing industries in which value added or other net output measures can be calculated directly. For other industries, the RDP indexes are based on gross output measures. In addition, there are a number of services-producing industries whose output has remained extremely difficult to measure. In such industries, which comprise most of the non-commercial sector of the economy as well as parts of the finance, insurance and real estate and commercial sector community, business and personal services industries, output is measured as the deflated value of identifiable inputs. The most important of these identifiable inputs is labour. In these industries, output measurement is judged to be poor in quality. Such measures cannot be used to generate meaningful estimates of productivity.(1)

Services-producing industries accounted for 59.4 per cent of RDP in 1971. Output measures at the major industry level are deemed to be good in the trade and hospital sectors, which together accounted for 14.6 per cent of 1971 RDP. The quality of output measurement in the transportation sector is felt to be fair to good. In other service industries, output measures are judged to be fair, from poor to fair, or poor in quality.

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(1) The basing of output measures on labour input measures in a number of large service sector industries may bias measured productivity downwards. Research at Statistics Canada into output measurement for savings and credit institutions found that "clearly ... a labour input (employment) proxy for output is heavy biased downwards and our results contradict the common assumption that productivity in many service industries is stagnant." See Measuring the Real Output and Productivity of Savings and Credit Institutions, Industry Product Division, Statistics Canada, mimeo., April 1977, p. 14.

Table 6

Overview of the Nature and Quality of Annual RDP Measures, Services-Producing Industries, Canada

Industry	Main Type of Output Measure(s)	Quality of Measure(1),(2)	1971 Percentage Share of Total RDP
Transportation, storage and communication(3)	value added, gross output	fair to good	8.6
Trade	gross output	good	11.6
Finance, insurance and real estate	net output, labour input	poor to fair	11.9
Community, business and personal services (commercial)	gross output, labour input	fair	9.0
Non-commercial services:			
Hospitals	gross output	good	3.0
All other (public administration, education, etc.)(4)	labour input	poor	15.5
All services-producing industries			59.4(5)

(1) The judgements of both the authors of this paper and Statistics Canada officials are reflected in the quality assessments provided in this table.
(2) The broad service industry groups for which output measurement quality is ranked as being poor to fair, or fair, each contain industries in which output is measured well. For example, in the finance component of finance, insurance and real estate, and in the accommodation and food services component of community, business and personal services, output measurement is judged to be good in quality.
(3) Excludes highway and bridge maintenance.
(4) Includes highway and bridge maintenance.
(5) Shares do not sum to the sector total because of rounding.

Source: See Table 5.

Considering goods- and services-producing industries together, those industries for which output measures at the aggregate level are judged to be good, or from fair to good in quality, accounted for 55-60 per cent of RDP in 1971. The remaining share of RDP was accounted for by major industries in which overall output measurement is judged to be fair, from poor to fair, or poor in quality.(1) The quality of the RDP indexes sets an upper bound on the quality of the productivity indexes. Difficulties associated with measuring labour input, although they tend to be less severe than the problems encountered in measuring output, nonetheless reduce the overall quality of the productivity indexes. The reliability of productivity indexes on an industry-by-industry basis is further reduced, to the extent that the industrial classifications of output and labour input do not match exactly.

It thus seems likely that labour productivity estimates of satisfactory accuracy are available for major industries producing not much more than 50 per cent of RDP.(2) This suggests that while the examination of economy-wide measures of productivity may be useful for some purposes, it is unlikely that possible structural changes underlying changes in productivity patterns can be isolated using aggregate data. The use of reliable data is a precondition for the empirical analysis of productivity movements. For this reason, the bulk of the empirical analysis of this paper focusses upon productivity growth rates in only those major industries in which the quality of output measurement is judged to be good, or from fair to good.

An important problem associated with the use of industry data which are judged to be of satisfactory quality is that productivity estimates, in particular those referring to the most recent years, are revised at least once a year. The revision process on the RDP side reflects the fact that, for a period of up to about three years after initial estimates are prepared, information which allows for an upgrading of the quality of estimates flows into Statistics Canada. For example, at the present time (April 1980), the latest year for which information from the Census of Manufactures has been incorporated into RDP estimates is 1976. Census of Manufactures results referring to 1977 are now being

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(1) It is worth re-emphasizing the point made at the beginning of the chapter, that the judgement that there is a large proportion of Canadian RDP which is not measured very accurately should not be interpreted as a criticism of Statistics Canada's methodologies in this area. The difficulties involved in measuring the outputs of many services-producing industries, and some goods-producing industries as well, are common to all industrialized countries. For a discussion of procedures used to estimate RDP in a number of countries, see, for example, United Nations Economic and Social Council (Statistical Commission), Country Practices in National Accounting at Constant Prices, 1974.

(2) As footnote 2 of Table 6 suggests, some major industries for which reliable productivity data are not available include some component industries in which good estimates of productivity may be calculated. If these smaller industries were included with major industries for which good productivity estimates are available, then substantially more than 50 per cent of RDP would be accounted for by such industries.

worked into RDP estimates; these will be reflected in revisions to productivity estimates for the manufacturing sector later this year. Establishment survey-based estimates of employment for recent years are also revised as new information becomes available. Revisions to employment estimates can have as large an impact on productivity estimates as changes made to RDP estimates.

Table 7 illustrates how important the revisions to estimates of output and employment growth have been in recent years. This table provides the various estimates of annual productivity growth since 1973 which have been published by Statistics Canada since 1976 for the manufacturing sector. Corresponding growth rates of output and employment are also provided in this table. As an orientation to the table, consider the growth rates of productivity (output per employee). The years in which particular estimates of productivity indexes were published are listed across the top of the table, while the years to which the estimates refer are given down the left side of the table. The table shows that the first estimate of productivity growth in manufacturing in 1974, published in 1976, was a 0.4-per-cent decline from the 1973 level. This estimate was revised in 1977 to positive growth of 1.4 per cent, then raised again in 1979 to a 1.7-per-cent growth rate. Productivity growth in manufacturing in 1976 was initially estimated (in 1977) as having been 3.5 per cent; this estimate was revised to 5.3 per cent in 1978, and to 5.5 per cent in 1979.

The data provided in Table 7 show that the most recent estimates of productivity growth by year in the manufacturing sector are, for every year, significantly different from the initial estimates. The table shows that revisions to both output and employment estimates have been responsible for changes in the estimated annual rates of productivity growth.

Estimated post-1973 productivity growth rates in commercial goods-producing industries exclusive of manufacturing and agriculture have also been revised very significantly, as estimates of output and employment growth have changed. Differences between the initial and most recent estimates of productivity growth in commercial services-producing industries, while significant, are not as large as in the case of the goods-producing industries, for most years since 1973. Tables comparable to Table 7, which show revisions made to output, employment and productivity growth in commercial goods-producing industries (exclusive of manufacturing and agriculture) and commercial services-producing industries, are provided in Appendix 2.

Productivity estimates referring to periods in the more distant past are also revised relatively frequently. Such revisions can reflect the ongoing process of Statistics Canada's receiving more information which can provide more accurate readings on output and employment growth in past years. They reflect other processes as well. When a new methodology is developed for estimation of output in a particular sector, for example, it is often possible to apply the methodology back over a number of years. The adoption of new estimation methodologies thus can result in revisions to estimates referring to years some distance in the past. This procedure in fact accounted for major historical revisions to some series in 1977.

Table 7

Various Estimates of Annual Percentage Increases in Output per Employee, Output, and Employment, Manufacturing Industries, Canada, 1974-1978

	Year Estimate Published			
	1976	1977	1978	1979
Output per Employee				
1974	-0.4	1.4	1.4	1.7
1975		-2.3	-3.2	-3.9
1976		3.5	5.3	5.5
1977			3.6	5.1
1978				6.1
Output				
1974	2.8	3.4	3.3	3.7
1975		-4.9	-5.5	-6.3
1976		5.1	5.3	5.7
1977			3.8	2.7
1978				7.8
Employment				
1974	3.3	2.0	2.0	2.0
1975		-2.6	-2.5	-2.5
1976		1.4	0.0	0.1
1977			0.1	-2.2
1978				1.6

Source: Statistics Canada, Aggregate Productivity Measures, Cat. 14-201, various issues: 1946-1974 (May 1976), 1946-1976 (November 1977), 1946-1977 (October 1978), 1946-1978 (October 1979).

Table 8 provides four estimates (calculated from data published in each of the years 1976 through 1979 inclusive) of average annual productivity growth during the periods 1957-1966 and 1967-1973, for the manufacturing, commercial goods-producing exclusive of manufacturing and agriculture, and the commercial services-producing sectors. The growth rates shown in Table 8 indicate that data revisions made during the past three years have led to fairly significant changes in estimates of productivity growth in major industries or industry groups. In manufacturing, for example, estimated average annual productivity growth over the period 1967-1973 has increased steadily, from 4.2 per cent (1976 estimate) to 4.5 per cent (1979 estimate). Revisions to output estimates (fourth column, Table 8) have been entirely responsible for these increases in estimated productivity growth. Downward revisions have been made since 1976 to estimated productivity growth in the commercial goods-producing industries exclusive of manufacturing and agriculture, in each of the periods 1957-1966 and 1967-1973; revisions to both output and employment estimates underly these revisions. Revisions similar to these have been made to the estimates for commercial services-producing industries.

Table 8

Various Estimates of Average Annual Percentage Increases in Output per Employee, Output, and Employment, Selected Industrial Sectors, Canada, 1957-1966 and 1967-1973

	Output per Employee		Output		Employment	
	1957-1966	1967-1973	1957-1966	1967-1973	1957-1966	1967-1973
Manufacturing						
Estimate published in:						
1976	3.8	4.2	5.2	5.1	1.4	0.8
1977	3.8	4.3	5.2	5.2	1.4	0.8
1978	3.8	4.4	5.2	5.3	1.4	0.8
1979	3.8	4.5	5.2	5.4	1.4	0.8
Commercial goods-producing ex. manufacturing and agriculture						
Estimate published in:						
1976	4.0	4.4	5.2	5.3	1.2	0.9
1977	3.9	4.2	5.1	5.3	1.2	1.0
1978	3.8	4.1	5.1	5.3	1.2	1.2
1979	3.8	4.0	5.1	5.3	1.2	1.2
Commercial services-producing						
Estimate published in:						
1976	1.4	2.2	4.8	5.6	3.4	3.4
1977	1.2	2.4	4.6	5.9	3.4	3.4
1978	1.2	2.1	4.6	6.0	3.4	3.8
1979	1.2	2.2	4.6	6.0	3.4	3.8

Source: Statistics Canada, Aggregate Productivity Measures, Cat. 14-201, various issues: 1946-1974 (May 1976), 1946-1976 (November 1977), 1946-1977 (October 1978), 1946-1978 (October 1979).

The size and extent of the revisions to productivity estimates in the manufacturing sector, as outlined in Table 7, indicate that a substantial degree of uncertainty must be attached to productivity estimates referring to the most recent years. It is therefore not certain how much productivity has increased or failed to increase since 1973, even in those industries for which the conceptual and statistical bases for output measurement are judged to be good. In addition, the data provided in Table 8 indicate that the benchmarks against which the post-1973 productivity performance is assessed change frequently themselves, and in some cases significantly. It is thus far from certain by how much productivity growth rates have in actual fact changed between the pre-1973 and post-1973 periods. The important impacts of revisions to estimates provide another major reason why the conclusions of empirical analysis of recent productivity movements (including the analysis contained in this paper) should be treated as being tentative in nature, and should be reviewed as better estimates of productivity changes become available.

3. AN EXAMINATION OF THE POST-1973 SLOWDOWN IN PRODUCTIVITY GROWTH

3.1 Main Patterns of Productivity Growth in the Postwar Period

Average annual rates of productivity growth during selected periods since World War II, by industry and by broad sector of the economy, are provided in Table 9. The first three periods for which data are presented are cyclically-neutral periods comprising one, or more than one, full business cycle. Average annual rates of productivity growth for these periods may thus be considered as being rough approximations to cyclically-adjusted rates.(1) Data for the period 1974-1978 are not cyclically comparable to those of the preceding periods, since 1974-1978 was a period of substantially slower growth, and the productivity growth rates for this period reflect to some extent the impact of the weak cyclical performance of the economy. Data are also provided for the slow growth years 1957-1961.

The sectors and industries included in the top panel of the table are most of those for which Statistics Canada publishes official productivity estimates.(2) The five industries for which data are shown in the bottom panel of the table are those other main industries for which productivity estimates are judged to be good, or from fair to good (see Tables 5 and 6 above). The table also provides, for comparative purposes, the growth rates of the economy-wide productivity measures discussed in Section 2.2.

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(1) The use of period average growth rates shows major breaks in trend rates of growth. It does not permit such breaks in trends to be identified as having occurred in any one particular year, however. In addition, the use of common time periods for all industrial sectors does not take account of the fact that activity peaks at different times in different sectors of the economy.

Regression analysis permits a more precise dating of changes in trend growth rates, and accommodates the possibility that cyclical peaks and troughs occur at different times in different sectors. The analysis of the impact of changes in capital-labour growth rates, which is presented in Section 3.2 below, utilizes cyclically-adjusted productivity growth rates calculated using regression techniques.

(2) See footnote 1, page 15 above.

Table 9

Average Annual Percentage Changes in Output per Person Employed, Selected Industries and Industry Groupings, Canada, Selected Periods

	1947-1956	1957-1966	1967-1973	1974-1978	1957-1961
Commercial sector	4.1	3.0	3.2	1.4	2.2
Commercial goods-producing sector	5.7	4.5	4.4	2.1	3.4
Commercial services-producing sector	1.3	1.2	2.2	0.9	0.7
Commercial non-agricultural sector	2.8	2.5	3.1	1.2	2.3
Commercial non-agricultural goods-producing sector	4.2	3.8	4.3	1.9	4.1
Agriculture	7.0	5.5	1.7	4.4	-1.2
Manufacturing	3.3	3.8	4.5	2.8	3.3
Fishing and trapping	5.7	-1.2	-0.4	4.3	1.8
Mines, quarries and oil wells	7.2	5.2	5.0	-4.2	6.8
Electric power and gas distribution	2.8	6.3	6.2	1.5	6.7
Transportation, storage and communication(1)	2.2	4.1	5.4	2.0	3.6
Trade	1.3	1.4	2.1	0.2	-0.2
Total economy (RDP basis)	3.6	2.2	2.6	1.1	1.2
Total economy (GNE basis)	3.5	2.1	2.5	0.5	1.2

(1) Excludes highway and bridge maintenance, which is classified as a non-commercial industry. Productivity estimates for the transportation sector cannot be separated from the overall estimates for transportation, storage and communication.

Source: Calculated from data supplied by the Industry Product Division, Statistics Canada, and data contained in Stat Can, National Income and Expenditure Accounts, Cat. 13-201, and The Labour Force, Cat. 71-001.

The most aggregate productivity measures (i.e., those referring to the total economy, or to the commercial sector of the economy) suggest that overall productivity growth slowed markedly between the cyclically-neutral periods 1947-1956 and 1957-1966. For example, the annual growth rate of output per person in the commercial sector fell by 1.1 percentage points on average between these periods, from 4.1 per cent in 1947-1956 to 3.0 per cent in 1957-1966. However, these comparisons are misleading, because of the presence in the aggregate productivity data of productivity growth rates for the agricultural sector. The productivity growth rate in this sector between any two years is determined largely by the sizes of the harvests in those years.(1) In considering aggregate productivity movements, it is thus preferable to focus upon a measure which excludes the agricultural sector.

(1) Output per person in agriculture increased by 7.0 per cent per year during the years 1947-1956 (see Table 9). The addition of one more year to this period (so that the period becomes 1947-1957) drops the period average productivity growth rate to 5.1 per cent per year. This is because the harvest was poor in 1957; agricultural output dropped by 16 per cent in that year.

In the commercial non-agricultural sector, output per person grew on average by 2.8 per cent per year over the years 1947-1956. The average growth rate of productivity in this sector then declined only marginally, to 2.5 per cent per year during the period 1957-1966. After 1966, productivity growth in this sector accelerated, averaging 3.1 per cent per year from 1967 to 1973.

Over most of the postwar period, then, and setting aside year-to-year irregular and cyclical fluctuations, output per person grew at a fairly steady rate, of about 2.5 to 3.0 per cent per year in the commercial non-agricultural sector of the economy. Against this pattern, the decline in the average rate of productivity growth after 1973 in this sector, to only 1.2 per cent per year, stands out very sharply. During the previous period of sustained slow growth, 1957-1961, productivity growth in the commercial non-agricultural sector averaged 2.3 per cent per year, an average rate of growth only 0.5 percentage points lower than that recorded from 1947 to 1956. The post-1973 drop in productivity growth in this sector was thus much more pronounced than that which occurred in the 1957-1961 period.

The data referring to particular industries which are provided in Table 9 show that sharp slowdowns in productivity growth have been recorded in most industries for which reasonably reliable data are available. Exceptions are agriculture and fishing and trapping. Productivity growth in agriculture accelerated between the periods 1967-1973 and 1974-1978; this worked towards reducing the extent of the measured productivity slowdown in the total economy or in the commercial sector, relative to the slowdown in the commercial non-agricultural sector.

The fishing industry is by far the largest component of the fishing and trapping sector. Productivity growth in fishing declined sharply between 1947-1956 and 1957-1961, and became negative between 1961 and 1973. Stagnant output growth, which was in large part related to the depletion of fish stocks, was responsible for much of the poor productivity performance of the industry over this period. Improved catches in recent years, attributable in large measure to the proclamation by Canada in 1977 of jurisdiction over a 200-mile offshore limit, have reversed the long-term decline in output in the industry. Positive average productivity growth has been recorded in the post-1973 period.

The other industries for which data are provided in Table 9 recorded very large declines in productivity growth rates in the post-1973 period. In only one of these industries - trade - does the post-1973 decline in productivity growth seem comparable to that registered during the previous major period of slow growth. The growth rate of output per person in the wholesale and retail trade sector fell by 1.5 percentage points per year on average (i.e., from 1.3 to -0.2 per cent) between 1947-1956 and 1957-1961; the corresponding decline between 1967-1973 and 1974-1978 in this sector was 1.9 percentage points (i.e, from 2.1 to 0.2 per cent). In the other industries - manufacturing, mines, quarries and oil wells, electric power and gas distribution, and transportation, storage and communication - post-1973 reductions in productivity growth rates were much more pronounced than were recorded during the slow-growth period 1957-1961.

The remaining sections of this chapter examine a number of non-cyclical factors which have been suggested as possible contributors to the post-1973 productivity slowdown. To the extent possible, the following analysis focusses upon developments at the level of individual industries or industry groups.

3.2 The Effect of Declining Productivity in the Oil- and Natural Gas-Related Industries

Referring again to Table 9, the sharpest declines in productivity growth at the industrial level between 1967-1973 and 1974-1978 have occurred in the mining, electric power and gas distribution, and transportation, storage and communication industries. The declines have been large in absolute terms; for example, in mines, quarries and oil wells the decline in the yearly average productivity growth rate between 1967-1973 and 1974-1978 was 9.2 percentage points. These patterns in productivity movements are much different from those recorded in these industries in the slow-growth years 1957-1961, relative to those of the preceding decade. Productivity growth in mines, quarries and oil wells fell only marginally between 1947-1956 and 1957-1961, from an average of 7.2 to 6.8 per cent per year. Between the same periods, productivity growth accelerated very sharply in the electric power and gas distribution industry (from 2.8 to 6.7 per cent per year) and significantly in the transportation, storage and communication industry (from 2.2 to 3.6 per cent annually).

An important part of the post-1973 productivity slowdown in these industries is attributable to an essentially non-cyclical decline in productivity in the oil- and natural gas-related industries.(1) This is evident from an examination of average annual rates of productivity growth for selected periods since 1961 for the mining, transportation, storage and communication, and electric power and gas distribution industries, and their oil and gas-related components, which are provided in Table 10. The productivity growth estimates for the sub-major-group industries shown in this table are unofficial estimates prepared by the authors; the data required to calculate these measures are available only since 1960.

Table 10 shows that output per person employed in the crude petroleum and natural gas industry declined on average by nearly 10 per cent per year during the five years 1974-1978, after growing at average annual rates of 7 per cent or more over the period 1962-1973. The dramatic reversal of productivity performance in this industry is attributable to both falling output and accelerating employment growth. The output of oil has declined significantly and the growth of domestic consumption has slowed markedly since 1973. In addition, policy decisions aimed at

(1) We owe this point to earlier work done by John Lester.

conserving energy resources for future domestic needs have been reflected in reductions in oil exports to the U.S. authorized by the National Energy Board (the NEB was given the power to restrict oil exports in 1973).(1) The output of natural gas, which grew rapidly in the 1961-1973 period, has fluctuated narrowly about its 1973 level over the years 1974-1978.(2) Employment, meanwhile, has grown more strongly than in the past.(3) Much of the increase in production-worker employment in the industry has occurred in the areas of development drilling and exploratory drilling. In addition, managerial, professional, technical and administrative staff expansion has been very rapid since 1973.(4)

The changed situation in the crude oil and natural gas extraction industry has had a major impact upon the rate of productivity growth in the overall mines, quarries and oil wells sector. In the industry as a whole, average annual productivity growth fell by 9.2 percentage points between 1967-1973 and 1974-1978. In mines, quarries and oil wells exclusive of the crude petroleum and natural gas sector, the corresponding decline in productivity growth rates was about half as large, 5.3 percentage points.

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(1) The production of crude petroleum, petroleum products and natural gas liquids, after rising steadily to a postwar maximum of 770 million barrels in 1973, fell to 576 million barrels in 1978. Over the same period, exports of crude petroleum products and natural gas liquids declined from about 492 million barrels to 180 million barrels. For a detailed discussion of developments in the energy sector during the 1970s, see the Economic Review, Department of Finance, April 1980.
(2) Factors particular to individual years have also affected oil and gas output since 1973. In this regard, see the various National Energy Board annual reports, and its Canadian Oil Supply and Requirements (February 1977).
(3) Official Statistics Canada data for employment in crude petroleum and natural gas extraction do not include employment in synthetic crude oil operations, because of confidentiality limitations on the publication of these data. Employment in synthetic operations is not included in the data from which the estimates provided in Table 10 have been calculated. Synthetic crude oil is included in estimated RDP for the industry, however. The estimated levels of labour productivity in the crude petroleum and natural gas industry, upon which the growth rates given in Table 10 are based, are thus overstated. In addition, because employment growth has been very significant in recent years in synthetic operations, and because these operations are relatively labour-intensive compared to traditional methods of extracting oil, the extent to which labour productivity in the industry has in fact declined is understated to some extent by the estimates given in Table 10.
(4) Statistics Canada, The Crude Petroleum and Natural Gas Industry, Cat. 26-213. Non-production workers account for about three-quarters of total employment in the crude petroleum and natural gas industry.

Table 10

Average Annual Percentage Changes in Output per Person Employed, Selected Components of the Mines, Quarries and Oil Wells; Transportation, Storage and Communication; and Electric Power and Gas Distribution Industries, Canada, Selected Periods

	1962-1966	1967-1973	1974-1978
Mines, quarries and oil wells	3.7	5.0	-4.2
Crude petroleum and natural gas	7.8	7.0	-9.7
Mines, quarries and oil wells excluding crude petroleum and natural gas	2.3	2.9	-2.4
Transportation, storage and communication	4.5	5.4	2.0
Pipelines	5.4	9.2	-7.8
Transportation, storage and communication excluding pipelines	4.4	5.0	2.5
Electric power and gas distribution	5.8	6.2	1.5
Gas distribution	11.6	8.0	0.7
Electric power	4.6	5.9	1.6

Source: Calculated from data supplied by the Industry Product and Labour Divisions, Statistics Canada, and data contained in Stat Can, Real Domestic Product by Industry, Cat. 61-213, General Review of the Mineral Industries, 1976, Cat. 26-201, Mineral Industries: Principal Statistics, Cat. 26-204, and Employment, Earnings and Hours, Cat. 72-002.

The fall in the production of crude oil and natural gas was matched by a fall in RDP in the pipelines sector, which was the major contributor to the 1974-1978 decline in productivity in this sector. Productivity growth rates in pipelines declined by an average of 17 percentage points per year from 1967-1973 to 1974-1978 (i.e., from 9.2 to -7.8 per cent). Although pipelines accounted for only 6.6 per cent of 1973 RDP in the transportation, storage and communication industry, the change in productivity growth in pipelines accounted for a much larger share of the overall productivity decline in the industry. Average annual productivity growth in the industry as a whole declined by 3.4 percentage points between the periods 1967-1973 and 1974-1978 (i.e., from 5.4 to 2.0 per cent); in the industry exclusive of the pipeline sector, the average annual decline was 2.5 percentage points.

A large decline in productivity growth was also recorded in the gas distribution industry after 1973. This change, of 7.3 percentage points per year on average, accounted for only a small share of the productivity decline in the electric power and gas distribution industry as a whole, however.

In order to illustrate the relative importance to aggregate productivity growth of the recent decline in productivity in the oil- and gas-related (i.e. both extraction and distribution) industries, a simple methodology has been used to relate this decline to the change in aggregate productivity growth. A hypothetical estimate of 1978 output and employment in the oil- and gas-related industries has been calculated, assuming that output and employment in these industries grew, after 1973, at their 1961-1973 trend rates of growth. Under this assumption, 1978 RDP in the oil- and gas-related industries would have been $4.1 billion (1971 dollars), almost double the $2.1 billion of output actually produced in these industries in that year. In addition, employment in these industries would have been about 36,000, a level significantly lower than the actual level of 42,600.

The differences between the hypothetical and actual output and employment levels in these industries are then used to adjust the actual economy-wide 1978 levels of output, employment, and productivity, to generate corresponding hypothetical estimates. Actual 1978 RDP is increased by $2.0 billion, and the aggregate level of employment in 1978 is reduced by 6,600. The resulting hypothetical estimate of 1978 aggregate RDP-based productivity is significantly higher than the actual figure. If these hypothetical figures had obtained, 1974-1978 (RDP-based) aggregate productivity growth would have averaged 1.45 to 1.50 per cent per year, rather than the 1.1-per-cent growth actually recorded. These figures suggest, then, that .35 to .40 percentage points of the average yearly decline in RDP-based productivity growth of 1.5 percentage points, or about one-quarter of the overall productivity slowdown, can be attributed to the effects of the changed situation after 1973 in the oil- and natural gas-related industries. It must be stressed, however, that given the simplicity of the methodology, and all the problems associated with data which were discussed above, this estimate should be treated as being indicative in nature, rather than as a precise estimate.(1)

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(1) The base year used for the preparation of constant dollar measures of output is currently 1971. Statistics Canada will rebase its constant dollar estimates sometime in the future. A new base year such as 1979, say, will capture the massive increase in the relative price of oil and gas which has occurred since 1973. Constant dollar estimates of oil and gas output based on, for example, 1979 prices, will account for a much larger share of total output than the 1971-price-based measures currently indicate. This implies that the post-1973 decline in aggregate productivity growth will be larger, all other things being equal, when output is measured in terms of 1979 prices than when output is measured in terms of the 1971 price structure. It also implies that the post-1973 fall in output in the oil- and natural gas-related industries will account for a larger share of the post-1973 aggregate productivity decline.

3.3 The Effect of the Decline in the Capital Intensity of Production(1)

The growth of the capital stock and increases in the capital-labour ratio have for a long time been associated with secular increases in output per person employed. However, the precise extent to which the growth of the capital intensity of production has contributed to the growth of labour productivity is a matter of substantial debate. Indeed, much of the analysis of this issue, particularly work based upon growth accounting techniques, has tended to minimize the importance for productivity growth of increases in the capital stock.(2)

This section reviews the patterns of movement of capital-labour ratios during the postwar period in the major commercial sectors of the Canadian economy, and analyzes the relationship between changes in the capital intensity of production and productivity growth. It must be noted that there are a number of serious problems associated with Canadian capital stock data.(3) These problems limit the reliability of estimated capital-labour ratios, in much the same way as the difficulties in estimating RDP in a number of sectors limit the reliability of labour productivity estimates. Consequently, the numerical estimates presented in this section must be considered as being indicative in nature, rather than very precise.

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(1) This section draws heavily on the paper Capital and Productivity in Canada,1947-1978, Paul Davenport, Department of Finance, mimeo, 1979.

(2) The concept of growth accounting is associated most often with the name of Edward F. Denison, who has written many works on the subject. Canadian studies of the sources of economic growth carried out within the growth accounting framework include N.H. Lithwick, Economic Growth in Canada (University of Toronto Press, Toronto, 1970) and Dorothy Walters, Canadian Income Levels and Growth (Economic Council of Canada, Staff Study No. 21, 1970).

Growth accounting estimates have tended to suggest that capital formation plays a relatively minor role in explaining labour productivity growth. For a discussion of this result, see Davenport, op. cit. pp. 6-8.

(3) Canadian capital stock estimates are prepared using the perpetual inventory methodology. Under this methodology, capital stock levels in each industry are increased each year by the amount of investment estimated to have occurred in the industry, and reduced by the amount of capital in the industry estimated to have been used up. Major problems encountered in the preparation of capital stock estimates include: difficulties associated with the deflation of some current dollar investment series; the need to estimate the useful working lives of a wide range of capital assets; and the necessity of making arbitrary assumptions regarding the depreciation of these assets. The methodology underlying the preparation of Canadian capital stock estimates is outlined in Statistics Canada, Fixed Capital Flows and Stocks 1972-1979, Cat. 13-211, and Fixed Capital Flows and Stocks, Manufacturing, Canada 1926-1960, Cat. 13-522.

The major conclusions of the section are that there has been a slowing in the trend rate of growth of capital-labour ratios in a number of important sectors, and that this appears to have contributed significantly to the post-1973 slowdown in productivity growth. Some factors which may have caused the growth rate of several sectoral capital-labour ratios to decline in the 1970s can be suggested; there remains, however, some uncertainty with respect to this issue.

Table 11 provides average annual percentage changes in capital-labour ratios in the major industries within the commercial sector of the Canadian economy, during the time periods which have been used throughout this paper. In some industries or industry groups (mining, electric power and gas distribution, and transportation, storage and communication), the rate of growth of the capital-labour ratio slowed significantly in the post-1973 period; in others (construction, finance, insurance and real estate and commercial community, business and personal services), however, the rate of growth of the capital intensity of production accelerated from 1967-1973 to 1974-1978. No significant change was recorded after 1973 in the rates of growth of the capital-labour ratios in the agriculture and other primary, manufacturing, and trade sectors,

Table 11

Average Annual Percentage Rates of Growth of Capital-Labour Ratios,(1) Selected Industries, Canada, Selected Periods

	1947-1956	1957-1966	1967-1973	1974-1978	1957-1961
Agricultural, forestry, fishing and trapping	10.1	5.4	4.7	4.8	5.4
Mines, quarries and oil wells	6.4	9.0	6.1	4.8	11.0
Manufacturing	2.9	3.4	3.9	4.2	5.6
Construction	5.8	0.4	3.1	3.6	5.4
Electric power and gas distribution	3.7	4.6	4.0	2.4	5.0
Transportation, storage and communication	0.4	2.6	2.0	1.2	5.0
Trade	3.6	1.2	-	-	2.5
Finance, insurance and real estate	0.4	5.3	3.1	4.3	6.1
Commercial community, business and personal services	-	-0.6	4.1	5.2	-1.1
Commercial sector total	3.9	3.0	2.8	2.9	4.8

(1) Capital stock estimates used here are year-end gross stocks of fixed capital.

Source: Statistics Canada, Fixed Capital Flows and Stocks, Cat. 13-211, and data supplied by the Industry Product Division.

nor for the commercial sector as a whole. Indeed, the commercial sector capital-labour ratio appears at first glance to have maintained a remarkably steady trend rate of growth of about 3.0 per cent since the mid-1950s.

A comparison such as this is misleading, however, since capital-labour ratios in at least some sectors of the economy exhibit pronounced cyclical patterns. The data in Table 12 illustrate this point. Table 12 provides the annual percentage changes in the capital-labour ratios for manufacturing and for the entire commercial sector since 1947, as well as yearly percentage changes in GNE as an indicator of cyclical movements in the economy. There is a clear counter-cyclical pattern to the increases in the capital-labour ratios shown in Table 12; increases in these ratios have tended to be highest in years of slow aggregate demand growth, and lower in periods of strong economic expansion.(1) The cyclical behaviour of employment growth accounts of course for part of the counter-cyclical behaviour of the growth in the capital-labour ratios. To the extent that investment growth lags the overall cycle (i.e. investment growth peaks after an output peak has been reached, and picks up more slowly than other components of output following a trough in activity), this represents an additional source of counter-cyclical behaviour in increases in capital-labour ratios.

It is thus evident that a comparison of post-1973 capital-labour ratio increases with those of previous cyclically-neutral periods does not answer the question as to whether the trend rates of growth of capital-labour ratios have changed. The period since 1973 has been one of slow growth; as was noted above, capital-labour ratios tend to grow most rapidly in periods of slow aggregate demand growth. It is thus necessary to adjust capital-labour ratios for cyclical influences, before conclusions regarding trend rates of growth and changes in those trend rates can be drawn.

One simple way of making a cyclically-corrected comparison is to examine the behaviour of capital-labour ratios in a period during which GNE growth was comparable to that of the post-1973 period. The only such period since the late 1940s has been the years 1957-1961. Average annual percentage increases in capital-labour ratios for the 1957-1961 period are provided in the final column of Table 11. A comparison of the data for the periods 1957-1961 and 1974-1978 shows that in all sectors except commercial community, business and personal services, the rate of increase of capital-labour ratios was lower in the post-1973 period, in most cases significantly. To the extent that these two periods are in fact comparable, the behaviour of capital-labour ratios in 1957-1961 and 1974-1978 suggests that the trend rate of growth of these ratios has fallen.

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(1) Other major industries in which counter-cyclical patterns in capital-labour ratio increases are clearly discernible include construction, transportation, storage and communication, and trade.

Table 12

Annual Percentage Increases in GNE and Capital-Labour Ratios in Manufacturing and in the Commercial Sector, Canada, 1947-1978

	GNE	Capital-Labour Ratio	
		Manufacturing	Commercial Sector
1947	4.3	-2.7	-0.6
1948	2.5	2.5	3.1
1949	3.8	1.8	3.2
1950	7.6	0.7	4.9
1951	5.0	-0.5	2.9
1952	8.9	3.7	4.9
1953	5.1	2.9	5.4
1954	-1.2	9.6	5.8
1955	9.4	2.9	2.5
1956	8.4	3.2	2.5
1957	2.4	6.2	4.8
1958	2.3	9.5	8.2
1959	3.8	3.0	2.9
1960	2.9	5.3	4.7
1961	2.8	4.2	3.7
1962	6.8	0.6	0.9
1963	5.2	0.5	1.3
1964	6.7	0.3	1.0
1965	6.7	1.3	0.7
1966	6.9	2.8	2.3
1967	3.3	5.4	3.4
1968	5.8	5.2	4.6
1969	5.3	2.8	1.7
1970	2.5	8.0	5.2
1971	6.9	5.1	3.3
1972	6.1	1.1	0.7
1973	7.5	0.1	1.0
1974	3.6	3.0	0.9
1975	1.2	7.1	4.8
1976	5.4	3.9	4.1
1977	2.4	6.0	2.8
1978	3.4	1.1	2.2

Source: Statistics Canada, National Income and Expenditure Accounts, Cat. 13-201, Fixed Capital Flows and Stocks, Cat. 13-211, and information supplied by the Industry Product Division.

Regression analysis can also be used to adjust growth rates of capital-labour ratios for the effects of cyclicality, and to explore the issue of whether the trend rate of growth of capital intensity has changed over time. Appendix 3 describes the specification of a regression equation which has been used to determine whether the cyclically-adjusted growth rates of capital-labour ratios in nine industrial sectors, and in the commercial sector of the economy as a whole, changed in the 1970s. The regression results are also provided in Appendix 3. In summary, these results are similar in qualitative terms to what is suggested by the comparison of data in Table 11 for the periods 1957-1961 and 1974-1978. The regression estimates show that the growth rates of cyclically-adjusted capital-labour ratios in most industries fell in the 1970s, while the reverse occurred in the commercial community, business and personal services sector. One difference in the results is that the regression estimates for agriculture and construction suggest no change in capital intensity growth (as opposed to the decline suggested by the data in Table 11). In addition, the regression analysis suggests that the decline in the rate of growth of capital-labour ratios may have started before 1973.(1)

In order to estimate the effect on productivity growth of the observed slowdown in the 1970s of sectoral cyclically-adjusted growth rates of capital-labour ratios, two additional calculations are required. First, it is necessary to estimate the extent to which sectoral cyclically-adjusted productivity growth rates declined in the 1970s; second, it is necessary to estimate the relationship between productivity growth changes and changes in capital intensity.

Estimates of the degree of decline in cyclically-adjusted productivity growth rates by sector during the 1970s have been calculated using a regression equation; the detailed regresssion results are provided in Appendix 3. Second, the relationship between productivity growth and changes in capital intensity has been estimated using a regression equation in which labour productivity is specified to be a function of the capital-labour ratio, capacity utilization variables, a time trend and a constant term. The detailed specification of the equation is given in Appendix 3. The equation was estimated for the major industry groups in which productivity estimates are judged to be good, or from fair to good, in quality.(2)

The regression results which are provided in Appendix 3 confirm the general expectation that movements in the capital-labour ratio are significantly related to productivity growth. The estimated coefficients of the capital-labour ratio variable are positive, with a high level of statistical significance, for all industries except trade. The relatively

(1) This point is discussed in more detail in Appendix 3.
(2) These industries include agriculture and other primary industries; mines, quarries and oil wells; manufacturing; electric power and gas distribution; transportation, storage and communication, and trade.

large size of the estimated coefficients indicates that growth in the capital intensity of production may be a more important contributor to productivity growth than is suggested, for example, in growth accounting literature.

Table 13 provides estimates by industry of the extent to which declines in the cyclically-adjusted growth rates of capital-labour ratios have reduced trend productivity growth rates in the period 1973-1978.(1,2) In the agriculture and other primary industries, regression analysis identified no breaks in trend rates of growth of capital-labour ratios, and no breaks in trend productivity growth rates, in the post-1972 period. In the case of trade, no relationship was identified between rates of growth of capital intensity and productivity. For these two industries, accordingly, Table 13 indicates that changes in capital-labour ratio growth rates have played no role in explaining post-1972 productivity changes. In the cases of the other four industries for which results are reported in Table 13 - mines, quarries and oil wells; manufacturing; electric power and gas distribution, and transportation, storage and communication - declines in trend capital intensity growth rates are estimated to have accounted for from 45 to 65 per cent of corresponding declines in trend rates of productivity growth in the post-1972 period. These four industries constitute the group of non-primary industries in which productivity estimates are the most reliable, and in which post-1973 productivity growth rate declines appear to have been larger than would be expected on the basis of cyclical factors alone (See Table 9).

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(1) The procedure by which the estimates given in Table 13 were calculated is as follows. First, estimates of the extent of decline of capital-labour ratio growth rates are taken from the regression results summarized in Table 21 of Appendix 3. Second, the estimated capital intensity coefficients provided in Table 23, Appendix 3, are combined with the estimates of Table 21 to generate estimates of the absolute impact on industry trend productivity growth rates of declining capital-labour ratio growth rates. Third, these estimates are expressed as percentages of the trend decline in industry productivity growth rates, using the estimates of Table 22, Appendix 3.

(2) Previous tables have referred to the period 1974-1978, because of the need to use cyclically-neutral periods in calculating average rates of growth for comparative purposes. With the use of regression analysis, more flexibility exists in the choice of time periods over which to examine changes in trends. The regression results suggested that changes in trend productivity growth rates may have occurred prior to 1974, although dating these changes precisely for each sector is difficult. Estimates comparable to those given in Table 13, but covering the period 1971-1978, are provided in Appendix 3.

Table 13

Estimated Proportion of Changes in Cyclically-Adjusted Productivity Growth Rates Accounted for by Changes in Capital-Labour Ratio Growth Rates, Selected Industries, Canada, 1973-1978

	(per cent)
Agriculture, forestry fishing and trapping	0
Mines, quarries and oil wells	45
Manufacturing	52
Electric power and gas distribution	65
Transportation, storage and communication	60
Trade	0

Source: Davenport, op. cit.; and Long Range and Structural Analysis Division, Department of Finance.

Aggregating the industry estimates given in Table 13, and applying the results to the post-1973 period suggests that about 25 per cent of the observed post-1973 slowdown in RDP-based productivity growth can be attributed to declines in the rate of growth of capital intensity in mines, quarries and oil wells; manufacturing; electric power and gas distribution, and transportation, storage and communication. This estimate should be interpreted as being indicative only, for a number of reasons. Any effects of changes in capital-labour ratio growth rates in sectors in which productivity is not well measured are not included in the aggregate impact measure. In addition, the estimates

are sensitive to whether gross capital stock or net capital stock data are used;(1) they may also be sensitive to the revisions made frequently to productivity and capital-labour ratio estimates.

There remains a good deal of uncertainty as to the factors that have caused capital intensity growth rates in a number of important industries to diverge in the 1970s from previous trends, thereby lowering productivity growth rates. A variety of different factors may have influenced these ratios. For example, the previous section noted that employment grew rapidly in the crude petroleum and natural gas portion of the mines, quarries and oil wells sector since 1973, reflecting heightened exploratory and development activity. The changed situation in the oil and gas industry thus probably affected capital-labour ratio growth rates as well as productivity directly. In turn, movements of the capital-labour ratio in the mines, quarries and oil wells industry as a whole in the post-1973 period may have reflected these developments in the crude petroleum and natural gas industry.

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(1) The sensitivity of results to the empirical specification of the capital stock variable is consistent with the results of some U.S. research in this area. See, for example, Peter K. Clark, "Capital Formation and the Recent Productivity Slowdown", The Journal of Finance, Vol. XXXIII, No. 3 (June 1978), pp. 965-975. Clark reports the results of estimating productivity functions for the private non-farm business sector of the U.S. economy. Coefficients on his capital/labour ratio variable fall in the .63 to .70 range when the gross capital stock is used, and in the .40 to .48 range when the net capital stock is used (p. 972).

A good indication of the imprecision involved in estimating the impact of changes in capital intensity growth on productivity growth can be obtained in reviewing statements made on this issue by the U.S. Council of Economic Advisors (CEA) over the past several years. In its 1977 Annual Report, the CEA noted that:

> Estimates of the contribution of increase in the capital-labor ratio to productivity growth are very sensitive to the measure of capital stock used; our analysis suggests that perhaps one-tenth to one-third of the productivity slowdown since 1966 can be explained by slower growth in effective capital per labor-hour. (CEA Annual Report, January 1977, p. 46).

In its Annual Report submitted January 1979, the CEA argued that up to one-half of the post-1973 productivity slowdown in the U.S. could be explained by slower growth in the capital stock. In its January 1980 Report, however, the CEA suggested that about 20 per cent of the 1973-1978 productivity slowdown could have been attributable to a slowing of the growth rate of the capital-labour ratio. At the same time, the CEA noted that some estimates available would put the impact higher (p. 87).

Other examples of industry-specific factors affecting capital-labour ratios (and productivity growth) in the U.S. have recently been noted by Martin Baily:

> Public utilities overestimated demand for electricity substantially. This led to cutbacks in investment and a stalling of productivity growth. Retail stores began to stay open much longer hours in the seventies. This caused a decline in the capital-labour ratio and a decline in measured productivity growth.(1)

Factors similar to these, and other industry-specific factors which have not yet been identified, may have contributed to the decline in capital-labour ratio growth rates in Canada as well in the 1970s. As the search continues for the explanation of reductions in capital intensity growth rates, special factors which may have impacted on individual industries should probably receive more attention.

It remains the case, however, that capital-labour ratio growth rates have declined across a wide range of industries in Canada. It is thus reasonable to look for more generalized factors which may have been responsible, at least in part, for this phenomenon. One such general factor would be a change in relative factor prices, which would lead employers to substitute labour for capital in their production processes. However, since the early 1960s, the cost of labour relative to capital appears to have risen rather than fallen in most years.(2)

Another general factor which should be considered is the 1973-1974 increase in the relative price of energy. A good deal of attention has been focussed on the potential effects on production processes of the increase in energy prices. The U.S. Council of Economic Advisors, for example, argues in its 1980 Report that:

> ... rapid increases in energy prices, if sustained, would make the operation of older energy-intensive equipment less profitable and may make some of our present knowledge less relevant. To the extent that energy and capital are complements in production, rising energy prices may slow the rate of growth of the capital-labour ratio, and labour productivity may fall.(3)

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(1) Martin Neil Baily, "Discussion of Productivity Growth", Brookings Papers on Economic Activity, (1979:2), p. 434.

(2) Department of Finance estimates suggest that relatively smooth growth in the user cost of capital occurred between 1963 and 1973. Over this period, the user cost of machinery and equipment and non-residential construction rose by 3.1 and 5.5 per cent per year on average respectively. Average compensation per employee in the commercial non-agricultural sector increased by 6.9 per cent over the same period. From 1974 through 1978, the user cost of machinery and equipment and non-residential construction rose by 8.5 and 7.4 per cent per year respectively, while commercial non-agricultural average compensation increased by an average of 10.5 per cent per year.

(3) Annual Report of the Council of Economic Advisors, United States Government, Washington, 1980, p. 87.

A substantial amount of empirical research is now available which suggests that capital and energy tend to be complementary inputs in the production process. The higher costs of energy inputs in the post-1973 period thus probably directly contributed, in a significant way, to the slowdown in capital-labour ratio growth in Canada.

The adjustment of technologies to higher energy prices may take some time, and is likely to continue in the future as energy costs are increased and the economy adjusts to a more energy-efficient production system. Although this could lead to some continued slowing in the growth of capital intensity while the adjustment is taking place, it does not necessarily imply that productivity growth would be permanently lowered once the adjustment process has been completed. The restructuring of the capital stock and the development of new energy-efficient production processes could bring with it broader technological advances and improvements in the growth of labour productivity.

3.4 The Effect of Other Factors Upon Productivity Growth

In the course of the public discussion of Canada's post-1973 productivity performance, a number of other factors have been suggested as having been possible contributors to the recent slow growth of productivity.(1) These factors include: changes in the demographic composition of the labour force; shifts in the industrial composition of employment towards services and away from goods; the expansion of governmental regulations, and in particular the imposition upon industry of pollution abatement requirements; and declines in average hours worked, which may make movements in output per person employed a misleading indicator of actual productivity growth in the economy. This section briefly examines each of these factors.

3.4.1 Changes in the Demographic Composition of the Labour Force

The skills and experience of the labour force have long been recognized as important determinants of the rate of productivity growth. The average educational level of the Canadian labour force has risen significantly over most of the postwar period, and continues to rise; by itself, this should have worked towards raising the rate of productivity growth in the economy. However, recent discussion of labour force quality and productivity growth has tended to focus on the changing demographic composition of the labour force, and to argue that this has been a depressing influence on aggregate productivity growth. Both women and young people are regarded as being less experienced, less skilled, and therefore less productive workers than prime-aged men. Empirical support for this view appears to be provided by the fact that the average wage and salary earnings of women and young persons are lower than those of prime-aged men. The conclusions are drawn that these lower wage earnings reflect lower average productivities, and

(1) See, for example, Edward A. Carmichael, Reassessing Canada's Potential Economic Growth, (The Conference Board in Canada, Ottawa, 1979); Sylvia Ostry and P.S. Rao, "Productivity Trends in Canada", Economic Council of Canada, mimeo, May 24, 1979, and Policy Review and Outlook, 1980 - Investing in Our Own Future, C.D. Howe Research Institute, (Montreal, 1980), Chapter 4.

that the expansion of the share of the labour force accounted for by women and young persons therefore tends to depress the growth of economy-wide output per person.(1)

This argument has been drawn on extensively, as offering a partial explanation for low rates of productivity growth in Canada in the 1970s.(2) There are, however, a number of problems with it, the first being that it is incomplete. An assessment of the effect of the changing quality of the labour force should encompass not only the effect of the changing composition of the labour force, but also the effect of higher education and skill levels of younger workers entering the labour force. Denison has estimated that, during the 1970s, changes in the quality of the U.S. labour force have worked in the direction of increasing productivity growth. Higher average education levels account for most of the increase in labour force quality which he measures.(3)

Second, male-female relative wage differentials are poor proxies for male-female productivity differentials. These wage differentials reflect the impact of a wide variety of factors, including discrimination against women in labour markets. Discrimination has been shown to have depressed the wage and salary earnings of women significantly vis-à-vis those of men in the U.S.; the same situation has been shown to exist in

(1) For a complete discussion of this argument, see George L. Perry's two important articles, "Changing Labor Markets and Inflation", Brookings Papers on Economic Activity, (3:1970), pp. 411-441, and "Labor Force Structure, Potential Output, and Productivity", Brookings Papers on Economic Activity, (3:1971), pp. 533-565.
(2) See, for example, Larry Blain, "Recent Developments in Aggregate Labour Productivity", Bank of Canada Review, January 1977, pp. 3-15; "Productivity in Canada", The Provincial Bank of Canada Economic Review, September-October 1977, pp. 1-6; Policy Review and Outlook, 1979: Anticipating the Unexpected, C.D. Howe Research Institute, Montreal, January 1979, pp. 64-65; and Carmichael, op. cit., p. 35.
(3) Edward F. Denison, Accounting for Slower Economic Growth, (Brookings Institute, Washington, D.C. 1979).

Canada.(1) Some of the estimates available for each country suggest that well over half of male-female earnings differentials are attributable to the effects of discrimination. Given this finding, the use of relative wage weights as proxies for productivity differentials discounts the contribution of women to output by too much. By itself, this suggests that observed relationships between changes in productivity growth and in the age-sex composition of the work force are in large measure spurious, since the major change in the composition of the labour force over the past 25 years has been the sharply increased share accounted for by women.(2)

A third and even more important problem with the argument that the demographic composition of the labour force and aggregate productivity are causally related was noted by William Nordhaus in an earlier examination of U.S. productivity growth:

> ... a large part of the increase in employment of females has taken place in industries where output is not measured with any precision. Thus about three-fourths of female workers are employed in services, trade, FIRE (finance, insurance and real estate) and government - all of which suffer from serious conceptual problems in the measurement of output.(3)

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(1) Important studies of sex discrimination in U.S. labour markets, and the impact of this discrimination on wage and salary differentials, include: Ronald Oaxaca, "Male-Female Wage Differentials in Urban Labor Markets", International Economic Review, Vol. 14, No. 3, October 1973, pp. 693-709; Alan S. Blinder, "Wage Discrimination, Reduced Form and Structural Estimates", The Journal of Human Resources, Vol. VIII, No. 4, Fall 1973, pp. 436-455; Robert P. Strauss and Francis W. Horvath, "Wage Rate Differences by Race and Sex in the U.S. Labour Market: 1960-1970", Economica, Vol. 43, No. 171, August 1976, pp. 287-298; and Victor R. Fuchs, "Differences in Hourly Earnings Between Men and Women", Monthly Labor Review, Vol. 94, No. 5, May 1971, pp. 9-15.

The main arguments of this literature are summarized in Hilda Kahne, "Economic Perspectives on the Roles of Women in the American Economy", Journal of Economic Literature, Vol. XIII, No. 4, Dec. 1975, pp. 1249-1292.

Canadian studies of sex discrimination in labour markets include: Morley Gunderson, "Male-Female Wage Differentials and the Impact of Equal Pay Legislation", The Review of Economics and Statistics, Vol. LVII, No. 4, November 1975, pp. 462-469, and "Decomposition of the Male/Female Earnings Differential: Canada 1970", The Canadian Journal of Economics, Vol. XII, No. 3, August 1979, pp. 479-485; William E. Schrank, "Sex Discrimination in Faculty Salaries: a Case Study", The Canadian Journal of Economics, Vol. X, No. 3, August 1977, pp. 411-433; and R.A. Holmes, "Male-Female Earnings Differentials in Canada", The Journal of Human Resources, Vol. XI, No. 1, Winter 1976, pp. 109-117.

(2) Between 1953 and 1975, the share of the Canadian labour force accounted for by women aged 20 and over rose from 18.1 to 30.2 per cent. The share accounted for by persons aged 14-19 rose from 10.1 to 11.5 per cent, while that of men aged 20 and over fell from 71.8 to 58.3 per cent.

(3) William D. Nordhaus, "The Recent Productivity Slowdown", Brookings Papers on Economic Activity (3:1972), pp. 493-536, p. 510.

Efforts to relate a changing age-sex employment mix to changing rates of aggregate productivity growth could thus be confounded by the poor quality of output measures in several industries. Put another way, a changing age-sex composition of the overall work force could be correlated with a declining measured rate of aggregate productivity growth resulting from shifts in employment (male or female) towards industries in which productivity growth is essentially defined as zero because of output measurement problems.

Table 14 provides the shares of total employment increases of men and women which occurred in industries in which output is well measured and not well measured,(1) respectively, during selected periods since the mid-1950s. In most of these periods, between 60 and 70 per cent of all employment growth of both men and women was generated within major industries in which the quality of output measurement is fair, from poor to fair, or poor. Thus the bulk of both female and male employment growth since the mid-1950s has occurred in industries in which little or no meaningful measurement of productivity is possible. It therefore is not meaningful to attempt to link changes in the demographic composition of employment to movements in a measure of aggregate productivity performance.(2)

It thus appears clear that whatever correlation has been observed between changes in the demographic composition of the labour force and changes in aggregate productivity growth rates(3) cannot be demonstrated to be a causal relationship. Observed differentials in average wages probably measure poorly the relative contribution of different demographic groups to production, primarily because a large element of these

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(1) See Chapter 2 and the footnote to Table 14 for the classification of industries by quality of output measurement.

(2) Manufacturing, trade, and transportation, storage and communication are the three major industries in the non-agricultural commercial sector in which output is measured well and in which the numbers of women employed are significant. It is interesting to note that in each of these industries, the employment share accounted for by women rose slowly between 1956 and 1966, then much more sharply from 1966 to 1973. The average annual growth rate of productivity in each of these industries accelerated between 1957-1966 and 1967-1973 (see Table 9). The employment share of women in each industry continued to rise sharply after 1973, while in each case productivity growth rates fell sharply. Thus in industries for which meaningful productivity estimates exist, there is no systematic correlation between the growth in labour productivity and changes in the employment shares of women.

(3) It is worth noting that the share of the labour force accounted for by adult women and young persons has grown at a relatively steady rate since the 1950s in Canada. Between 1957-1966 and 1967-1973, however, aggregate productivity growth accelerated; it decelerated only after 1973. This is a different pattern from that observed in the U.S., where the rate of aggregate productivity growth has declined since the mid-1960s.

Table 14

Percentage Shares of Employment Increases by Sex, in Industries Classified by Quality of Output Measurement, Canada, Selected Periods

Classification of Industries by Quality of Output Measurement(1)	1957-1966		1967-1973		1974-1978	
	Men	Women	Men	Women	Men	Women
Output measured well	9.5	35.1	39.9	32.4	35.0	29.8
Output not measured well	90.5	64.9	60.1	67.6	65.0	70.2

(1) Tables 5 and 6, Chapter 2, have been used as a guide to classify industries with respect to whether output is or is not well measured. Because labour force survey employment estimates have been used in this table, it has been necessary to include the smaller industries identified separately in Tables 5 and 6 with the major group of which they are a part. Industries in which output is designated as being measured well include agriculture, fishing and trapping, mining, manufacturing, utilities (including water systems), transportation, storage, communication and trade. Industries classified as ones in which output is not measured well include forestry, construction, finance, insurance and real estate, community, business and personal services (including hospitals) and public administration and defence.

Source: Statistics Canada, The Labour Force, Cat. 71-001; and Long Range and Structural Analysis Division, Department of Finance.

wage differentials reflects labour market discrimination. More important, however, aggregate output and productivity measures themselves do not accurately reflect the contribution to output and productivity of most persons (men and women both) who have joined the labour force since the 1950s, since the bulk of employment increases since that time have occurred in industries in which output is not well measured.

3.4.2 The Shift in the Share of Employment from Goods-Producing to Services-Producing Industries

Aggregate productivity growth rates are sometimes decomposed arithmetically into a component reflecting the effect on aggregate productivity of productivity growth in individual sectors, and a second component measuring the effect of shifts in the industrial composition of employment. This technique might have been used to provide an estimate of the effect on post-1973 aggregate productivity growth of changes in sectoral employment shares. It has not been, however, for two reasons. First, it is difficult if not impossible to assess what component of post-1973 employment composition changes is the result of ongoing secular or structural forces, which is what the analysis should focus on, and what portion reflects cyclical movements of the economy. Second, there are serious problems with the productivity estimates for a number of important sectors of the economy, as this paper has emphasized. These problems weaken the reliability of this type of decomposition analysis, which requires that productivity growth rates for all sectors of the economy be used in the calculations.

Notwithstanding these limitations, there remains a general argument with respect to employment composition effects which can be dealt with here, although not in a completely satisfactory way. This is the frequently-made argument that the growing share of employment accounted for by service industries works to depress aggregate productivity growth, since productivity growth tends to be lower in services-producing than in goods-producing industries. The expectation that employment will continue to shift towards service industries is also often put forward as a factor which will tend to depress productivity growth in the future.

An examination of changes in productivity growth rates between 1957-1966 and 1967-1973 provides some perspective on this argument. Since these were cyclically-neutral periods, the increase in the service sector share of employment which occurred between 1957-1966 and 1967-1973 can be interpreted as a secular change. In addition, the data for these periods will not be subject to as much revision as can be expected in post-1973 data; in this respect, they are more reliable. The problem with the weakness of data for several industry groups, primarily within the services-producing sector, nevertheless remains.

With this qualification in mind, the data show that a secular shift of the composition of employment towards the service sector need not be accompanied by declining aggregate productivity growth rates. Between 1956 and 1973, the share of employment in Canada accounted for by services-producing industries rose significantly. Despite this, the growth of commercial non-agricultural sector productivity accelerated over the period, rising from an average annual rate of growth of 2.5 per cent, 1957 through 1966, to an average yearly growth rate of 3.1 per cent over the period 1967-1973 (see Table 9). A very sharp increase in the measured average annual growth rate of productivity in the commercial services industries (from 1.2 per cent 1957-1966 to 2.2 per cent 1967-1973)(1), and a smaller increase in the growth of productivity in the non-agricultural goods-producing sector, offset the greater share of total employment accounted for in the latter period by the service sector. Canada's experience between the mid-1950s and the early 1970s thus indicates that the growth of the share of employment accounted for by the service sector does not automatically mean that aggregate productivity growth will decline.

3.4.3 Pollution-Abatement Expenditures

Another argument which has been made frequently in recent years is that increases in the degree of governmental regulation of the economy have imposed significant new costs on business. One particular area of controversy has been the issue of pollution abatement regulations and their impact on economic growth. The view has been expressed that the post-1973 slowdown in productivity growth may be attributable in part to regulations requiring that increased resources be devoted to pollution abatement and environmental protection.

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(1) Within the services-producing industries, productivity data for the trade sector are classified as being good in quality (see Table 6). The average annual productivity growth rate in trade rose from 1.4 per cent in 1957-1966 to 2.1 per cent in 1967-1973.

Table 15 provides estimates of capital expenditures in Canada on air and water pollution abatement equipment for the years 1970-1975. These estimates reflect expenditures reported for taxation purposes under accelerated capital cost allowance provisions relating specifically to water and air pollution equipment. There is a possibility that these data do not reflect all expenditures on such equipment, because claims for accelerated capital cost allowance treatment may have been made under more general tax provisions. For example, claims for accelerated capital cost treatment of pollution abatement equipment within manufacturing may be made under accelerated capital cost allowance provisions for manufacturing and processing equipment of 1972; expenditures on equipment for which claims were made under the general manufacturing provisions would not appear in the data of Table 15.(1) On the other hand, however, one independent source of data does suggest that the profile of expenditures given in Table 15 adequately reflects actual expenditures made.(2)

Table 15

Capital Expenditures on Air and Water Pollution Abatement Equipment, All Industries, Canada, 1970-1975

	Expenditures		
	($ millions)	as per cent of GNE ($ current)	as per cent of business non-residential investment ($ current)
1970	10.6	.01	.09
1971	121.3	.13	.99
1972	136.9	.13	1.03
1973	60.6	.05	.38
1974	47.6	.03	.24
1975	34.0	.02	.14

Source: Statistics Canada, Water and Air Pollution Abatement Expenditures 1970-1975, and National Income and Expenditure Accounts, Cat. 13-201.

The data indicate that capital expenditures on air and water pollution abatement equipment were very small in most years from 1970 to 1975. Only in 1971 and 1972 did such expenditures account for as much as 1.0 per cent of total business non-residential investment, and exceed 0.1 per cent of the value of GNE.

(1) Statistics Canada, Water and Air Pollution Abatement Expenditures, 1970-1975, p. 6.

(2) Air and water pollution abatement equipment qualifies for a rebate of sales tax paid in Ontario. Ontario sales tax data may thus be used as a check on the data reported in Table 16. The Ontario data are in fact consistent with the Statistics Canada data. Capital expenditures on pollution abatement equipment in Ontario over the period 1970-1975, as reported by Statistics Canada, were $228.6 million. For the fiscal years 1970-1971 to 1975-1976, Ontario sales tax data imply a total spending of $201.4 million on such equipment.

To leave the discussion at this point would be somewhat misleading, however, since capital expenditures on pollution abatement equipment in Canada have been concentrated in the manufacturing sector. Of the cumulative 1970-1975 total of $411 million of such expenditures (Table 15, first column), $327.2 million, or almost 80 per cent of the total, were made by industries within the manufacturing sector. These expenditures represented 1.4 per cent of the total value of new investment in manufacturing in Canada over this six-year period. In 1971 and 1972 respectively, 3.2 and 3.7 per cent of the value of gross fixed capital expenditure in manufacturing was accounted for by pollution-abatement-associated spending. The share of new investment in the early 1970s accounted for by pollution abatement equipment may have been large enough to have affected measured productivity growth in the manufacturing sector.

Two other points in this regard should be noted. First, total expenditure on pollution abatement includes both current and capital expenditures. A full assessment of the impact of pollution abatement expenditure on output and productivity growth must take account of both capital and current expenditures. No data on current as opposed to capital expenditure on pollution abatement are available for Canada. In the U.S., these current expenditures are large; in 1975, for example, they are estimated to have accounted for nearly 60 per cent of all air and water pollution abatement expenditures.(1) Second, the capital expenditure data reviewed here refer only to identifiable pollution-abatement-related equipment. To the extent that environmental regulations force major redesigns of equipment and processes, some pollution-abatement-related expenditure may not be identifiable as such.

For both of these reasons, then, the data examined in this section undoubtedly understate the degree of expenditure on pollution abatement which has occurred in Canada. For this reason, the impact of pollution abatement expenditure on productivity growth remains uncertain at this time.

3.4.4 Declines in Average Hours Worked

In Canada, as in the U.S., there has been a small but steady decline in average hours worked over much of the postwar period. The tendency for hours worked per employed person to decline is why, in any one period, output per person has almost always grown less rapidly than output per man-hour. In terms of assessing whether declines in average hours worked per employee contributed to the post-1973 productivity (output per person) slowdown, the relevant question is whether the rate at which average hours were declining accelerated after 1973. Such an acceleration would imply that the growth of output per man-hour would decline less than the growth in output per employee; in this case, the change in average hours worked could be viewed as having contributed to the slowdown in the growth of output per person.

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(1) Edward F. Denison, "Effects of Selected Changes in the Institutional and Human Environment Upon Output per Unit of Input", Survey of Current Business, Vol. 59, No. 1 (January 1978), pp. 21-44, p. 26.

Table 16 provides the estimated average annual percentage rates of decline in hours worked per employee, for the main sectors of the economy and for manufacturing. In most of the groups of industries for which data are provided in Table 16, average hours worked declined less quickly after 1973 than during previous periods. These data indicate that changes in average hours worked did not contribute to the post-1973 slowdown in the growth of output per person. Indeed, this slowdown would have been slightly more pronounced, had average hours worked declined in the post-1973 period at their 1967-1973 rate of decline.

Table 16

Average Annual Percentage Declines in Average Hours Worked, Selected Sectors, Canada, Selected Periods

	1947-1956	1957-1966	1967-1973	1974-1978	1957-1961
Commercial sector	-0.8	-0.7	-0.7	-0.6	-0.8
Commercial goods-producing sector	-0.7	-0.6	-0.6	-0.3	-0.8
Commercial services-producing sector	-0.8	-0.7	-0.8	-0.7	-0.6
Commercial non-agricultural goods-producing sector	-0.5	-0.2	-0.5	-0.1	-0.5
Manufacturing	-0.7	-0.1	-0.4	-	-0.4

Source: Statistics Canada, Aggregate Productivity Measures 1946-1978, Cat.14-201.

4. SUMMARY AND CONCLUSIONS

This paper has examined productivity patterns in the 1974-1978 period in some detail, attempting to assess the extent to which the post-1973 slowdown in productivity growth rates was attributable to structural factors, and thus reflected a decline in the trend rate of productivity growth. Considerable attention has been paid to the main characteristics of Canada's productivity statistics, and an effort has been made not to draw stronger conclusions from the empirical analysis than in fact can be supported by the data.

The main results and conclusions of the paper can be summarized as follows. First, it is not at all clear by exactly how much aggregate productivity growth rates have fallen in Canada in the post-1973 period. GNE-based and RDP-based productivity measures give different readings on this issue. GNE-based productivity growth averaged 0.5 per cent per year 1974-1978, a rate of increase only one-fifth as large as the 2.5-per-cent average growth in this measure recorded over the 1967-1973 period. The RDP-based aggregate productivity measure has grown at an average rate of 1.1 per cent per year from 1974 through 1978; this is a rate of growth slightly more than two-fifths as large as the 2.6-per-cent growth rate of this measure which obtained over the 1967-1973 period. There is thus a good possibility that the post-1973 decline in productivity growth has not been as large as the widely-discussed movements in GNE per employed worker would suggest.

Second, the characteristics of Canada's productivity data suggest strongly that structural factors which may have depressed productivity growth in the post-1973 period are unlikely to be identified through the analysis of aggregate-level productivity data. It seems clear that efforts to identify such factors must be focussed upon patterns of productivity change in industries for which reliable measures of productivity are available.

Third, two non-cyclical factors which have had a significant downward impact upon post-1973 productivity growth rates - the changed situation in the oil- and natural gas-related industries, and slower growth in capital-labour ratios in a number of industries - have been identified. The size of the impact on post-1973 aggregate productivity growth of the non-cyclical fall in productivity in the oil- and gas-related industries is estimated to be about one-quarter of the overall decline in RDP-based aggregate productivity growth. Similarly, about 25 per cent of the post-1973 decline in RDP-based productivity growth appears to have been attributable to declines in the growth rates of capital-labour ratios in the 1970s. These two factors together thus may have accounted for about half of the overall post-1973 productivity slowdown. Four other factors examined in Chapter 3 appear not to have had a significant or measurable impact on productivity gr[illegible]ver this period. All of these results are summarized in Table 17.

Table 17

A Qualitative Summary of the Estimated Effects of Selected Factors on Productivity Growth, 1974-1978

		Impact
1.	Productivity decline in the oil- and gas-related industries	Significant
2.	Slower growth in capital-labour ratios	Significant
3.	Changes in the demographic composition of the labour force	Not Significant
4.	Shifts in the share of employment from goods-producing to services-producing industries	Not Significant
5.	Governmental pollution-abatement regulations	Uncertain
6.	Changes in average hours worked per employee	Not Significant

Source: Long Range and Structural Analysis Division, Department of Finance.

APPENDIX 1: QUARTERLY RATES OF CHANGE OF GNE, EMPLOYMENT, AND GNE PER EMPLOYED PERSON, SINCE 1973

The examination of quarterly data provides a further perspective on the relationship between output and productivity growth since 1973. Table 18 presents quarter-to-quarter percentage rates of change in GNE, employment, and GNE per employed person from the first quarter of 1973 to the last quarter of 1979.(1) From the beginning of 1973 until into 1978, the quarterly estimates show some tendency for changes in employment growth rates to move in the same direction as changes in output growth rates, but with a time lag, and to be smaller than output changes. Consequently, there is a pronounced cyclical pattern to the quarterly rates of growth of productivity between early 1973 and late 1977-early 1978: strong rates of growth through 1973 (with the exception of the second quarter), declining productivity throughout 1974 as the Canadian economy experienced a recession, positive and strong productivity growth over the period 1975 III to 1976 II as output growth resumed strongly, lower rates of growth or declines in productivity as output growth moderated in late 1976 and early 1977, and a brief upturn followed by another downturn in late 1977-early 1978. After the first quarter of 1978, however, this type of pattern is for the most part no longer evident in the data. Employment changes in most quarters of 1978 and 1979 have tended to be roughly equal in magnitude and timing to output changes, so that no productivity growth has occurred in these quarters.(2)

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(1) GNE per employed person does not provide as good an indication of the cyclical sensitivity of productivity as does output per person in the commercial non-agricultural sector. This point was discussed in footnote 2, page 2. However, GNE per employed person can be estimated on a quarterly basis. Quarterly estimates of productivity in the commercial non-agricultural sector are not available.

(2) Preliminary GNE estimates are revised a number of times before being finalized by Statistics Canada. The quarterly growth patterns outlined here, as well as annual rates of GNE growth, could conceivably change significantly as a result of future revisions.

Table 18

Quarterly Percentage Rates of Change(1) of GNE and GNE per Employed Person, Canada, 1973-1979

		GNE	Employment	GNE/Employed Person
1973	I	3.6	2.2	1.3
	II	0.5	1.9	-1.4
	III	0.9	-0.2	1.1
	IV	2.6	1.5	1.1
1974	I	1.4	1.5	-0.1
	II	-0.5	0.7	-1.2
	III	-0.1	0.9	-1.0
	IV	0.1	0.6	-0.5
1975	I	0.1	-0.5	0.6
	II	0.5	0.9	-0.4
	III	1.2	0.6	0.6
	IV	1.0	0.9	0.2
1976	I	3.0	0.8	2.2
	II	1.2	-0.2	1.5
	III	-0.4	0.7	-1.1
	IV	0.5	-0.2	0.7
1977	I	0.9	0.7	0.2
	II	0.5	0.5	-
	III	0.5	0.6	-0.2
	IV	1.4	0.6	0.8
1978	I	0.6	1.0	-0.4
	II	0.9	1.0	-0.1
	III	1.1	1.1	-
	IV	0.7	0.7	-
1979	I	1.5	1.3	0.1
	II	-0.6	0.5	-1.1
	III	1.1	1.1	-
	IV	0.2	1.2	-1.0

(1) The quarterly percentage rates of change provided in the table are calculated using seasonally adjusted data.

Source: Statistics Canada, National Income and Expenditure Accounts, Cat. 13-001, and The Labour Force, Cat. 71-001.

APPENDIX 2: REVISIONS TO PRODUCTIVITY ESTIMATES, SELECTED INDUSTRIES

Tables 19 and 20 provide the various estimates of annual productivity growth since 1973 which have been published by Statistics Canada for, respectively, commercial goods-producing industries exclusive of manufacturing and agriculture, and commercial services-producing industries. The patterns of revisions to estimates in these tables were discussed briefly in the text, in Section 2.3.

Table 19

Various Estimates of Annual Percentage Increases in Output per Employee, Output, and Employment, Commercial Goods-Producing Industries excluding Manufacturing and Agriculture, Canada, 1974-1978

	Year Estimate Published			
	1976	1977	1978	1979
Output per Employee				
1974	-3.6	-1.2	-1.6	-1.7
1975		-0.5	-1.4	-1.3
1976		0.6	3.4	3.4
1977			-1.2	-0.9
1978				1.5
Output				
1974	0.5	3.0	2.9	2.8
1975		-1.5	-1.8	-1.6
1976		2.9	5.3	6.0
1977			1.5	2.0
1978				-0.6
Employment				
1974	4.3	4.3	4.6	4.6
1975		-1.0	-0.3	-0.3
1976		2.3	1.7	2.5
1977			2.8	2.8
1978				-2.1

Source: Statistics Canada, Aggregate Productivity Measures, Cat. 14-201, various issues: 1946-1974 (May 1976), 1946-1976 (November 1977), 1946-1977 (October 1978), 1946-1978 (October 1979).

Table 20

Various Estimates of Annual Percentage Increases in Output per Employee, Output, and Employment, Commercial Services-Producing Industries, Canada, 1974-1978

	Year Estimate Published			
	1976	1977	1978	1979
Output per Employee				
1974	-0.2	0.1	-0.7	-0.1
1975		0.8	0.7	1.0
1976		2.3	3.7	3.7
1977			0.1	-0.5
1978				0.4
Output				
1974	6.1	6.5	6.4	7.0
1975		3.3	3.6	3.9
1976		5.7	5.9	5.9
1977			4.2	4.1
1978				4.3
Employment				
1974	6.3	6.4	7.1	7.1
1975		2.6	2.9	2.9
1976		3.4	2.2	2.2
1977			4.1	4.6
1978				4.0

Source: Statistics Canada, Aggregate Productivity Measures, Cat. 14-201, various issues: 1946-1974 (May 1976), 1946-1976 (November 1977), 1946-1977 (October 1978), 1946-1978 (October 1979).

APPENDIX 3: CAPITAL AND PRODUCTIVITY

This appendix reports the empirical results upon which the analysis in Section 3.2 of the effect of changes in capital-labour ratio growth rates in the 1970s is based. Before turning to the results, however, it is useful to review briefly alternative ways in which economists have attempted to measure the relationship between capital and output.(1)

A.3.1 Theoretical Considerations

The theoretical basis of growth accounting may be illustrated(2) with a constant-returns-to-scale Cobb-Douglas production function,

$$Q = Be^{mt} K^{b} L^{1-b} \qquad (1)$$

where Q, K, and L are output, capital and labour respectively, B is a constant, m is a technical change parameter, and b is the elasticity of output with respect to capital. Dividing both sides of (1) by L yields

$$q = Be^{mt} k^{b} \qquad (2)$$

where q and k are output per person employed and the capital-labour ratio, respectively. Equation (2) can be transformed into a relationship in which the growth of output per employed person is determined by the growth of the capital-labour ratio, and the rate of technical change:

$$\dot{q} = m + b\dot{k} \qquad (3)$$

where $(\dot{})$ denotes the proportional rate of growth of a variable. Equation (3) represents a simplified growth accounting framework, in which $b\dot{k}$ is that part of the growth of productivity accounted for by growth in the capital-labour ratio, and m represents a residually-estimated technical change parameter.

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(1) More detail is available in Paul Davenport, Capital and Productivity in Canada, 1947-1978, mimeo.

(2) In this regard, see Robert M. Solow's important early article, "Technical Change and the Aggregate Production Function", Review of Economics and Statistics, Vol. 39, No. 3 (August 1957), pp. 312-320.

Within this simple growth accounting framework, b is estimated as the share of profit in national income. This procedure depends upon the assumption that the average rate of profit in the economy is equal to the marginal product of the economy's capital stock, which implies that the elasticity of output with respect to capital (b) equals the share of profits in national income. Given that the profit share in income is relatively low (generally 20 to 30 per cent) and that the trend growth rates of output and capital tend to be similar, it follows that the growth accounting methodology attributes a relatively small proportion of productivity growth to the growth in capital intensity. For example, Solow estimated in 1957 that only about one-eighth of the growth in productivity in the U.S. over the period 1909-1949 was due to growth in capital per employed person.(1) N.H. Lithwick's estimates for Canada are very similar: he found that only one-eighth of Canadian productivity growth from 1936 to 1956 was attributable to the growth in capital intensity, with the great bulk of the remainder being attributable to residually-determined technical change.(2) Dorothy Walters concluded that growth in the capital-labour ratio accounted for 31 and 15 per cent of productivity growth over the periods 1950-1962 and 1962-1967 respectively, with, again, most of productivity growth over these periods being accounted for by the technical change residual.(3)

While growth accounting yields easily computed and apparently precise estimates of the contribution of the growth of capital intensity to productivity growth, there is no good reason to believe that the crucial assumption of equality between the capital elasticity of output and the profit share of income accurately reflects reality. This assumption is derived from the partial equilibrium analysis of an individual firm in a perfectly competitive environment; the general equilibrium behaviour of capital and profits may be quite different.(4) It is precisely this assumption, however, which produces the result that most productivity growth is attributable to technical change independent of capital intensity. This result is difficult to interpret: much long-term technical change seems to require increases in the capital stock.

Marvin Frankel has provided an interesting interpretation of the tendency of the growth accounting assumptions to lead to an underestimate of the importance of capital as a factor in productivity growth.(5) Frankel

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(1) Solow, op. cit.
(2) N.H. Lithwick, Economic Growth in Canada, (University of Toronto Press, Toronto, 1970).
(3) Dorothy Walters, Canadian Income Levels and Growth, (Economic Council of Canada, Staff Study No. 21, Ottawa, 1970).
(4) This is the main conclusion of the recent "controversies" in capital theory; cf. G.C. Harcourt, Some Cambridge Controversies in the Theory of Capital, (Cambridge University Press, Cambridge, 1972).
(5) Marvin Frankel, "The Production Function in Allocation and Growth: A Synthesis", American Economic Review, Vol. 52, No. 5 (December 1962), pp. 995-1022.

interpreted equation (2) above as an ex ante production function faced by each of n identical firms in the economy. The parameter B, however, is a variable dependent upon the total capital-labour ratio in the economy;(1) Frankel assumed that

$$B = B_0 k^c \qquad (4)$$

Frankel called B the "development modifier"; it is a measure of the benefits of capital accumulation which are external to an individual firm, and are thus not captured by the assumption that factor returns equal marginal productivities. Given the formulation of (4), B would be constant if one firm expanded its capital-labour ratio, since individual firms are assumed to be too small to affect the aggregate capital-labour ratio. If all firms expanded their capital-labour ratios, however, equation 2 would be rewritten, with the substitution for B from equation (4), as

$$q = B_0 e^{mt} k^{b + c} \qquad (5)$$

In this formulation, the economy-wide capital elasticity of output is b + c; even if the marginal productivity assumptions held at the level of the firm, and the profit share of income were equal to b, the income share of profit would still understate the importance of capital to productivity growth because the external benefits reflected in the parameter c would be neglected.

A second way to assess the importance of capital in productivity growth is to use regression analysis to estimate the parameters of an equation like (1) or (2) directly. For example, taking logs in (2) yields

$$\log q = a_0 + mt + b \log k, \qquad (6)$$

where $a_0 = \log B$ is a constant. Two sorts of problems may arise in the specification of equations like (6): the use of marginal productivity constraints on the parameters, and failure to correct for cyclical fluctuations of aggregate variables.

In much of the regression work on production and productivity functions, parameters are constrained to obey marginal productivity assumptions. This is especially true in the case of estimates of the constant elasticity of substitution (CES) production function, a form more general than the Cobb-Douglas function.(2) CES production functions are usually

(1) Since the n firms are identical, the economy-wide capital-labour ratio equals the capital-labour ratio of each firm.
(2) K.J. Arrow, H.B. Chenery, B. Minhas, and R.M. Solow, "Capital-Labour Substitution and Economic Efficiency", Review of Economics and Statistics, Vol. 43, No. 3 (August 1961), pp. 225-250. See also Y. Kotowitz, "Capital-Labour Substitution in Canadian Manufacturing 1926-39 and 1946-61", Canadian Journal of Economics, Vol. 1, No. 3 (August 1968), pp. 619-632.

estimated in a two-step procedure. In the first step, the function is differentiated and the elasticity of substitution is estimated on the assumption that the wage rate equals the marginal product of labour. In a constant returns to scale function, this is equivalent to the capital productivity-profit rate constraint used in growth accounting. The use of this constraint in regression analysis generates results similar to those of growth accounting with respect to the importance of capital in productivity growth. This procedure suffers from the same weaknesses to which the growth accounting methodology is subject. It seems preferable, therefore, not to constrain parameters in regression analysis of the determinants of productivity growth.(1)

A second general problem with the specification of productivity equations is a failure to correct for cyclical fluctuations. Functions like (1) and (2) are designed to show the relationships among output, capital and labour at some standard or normal level of capacity utilization. These normal-capacity relationships are different from those which occur in the short run, during which output and employment can fluctuate substantially but capital may be considered as fixed. It would seem clear, therefore, that some correction for cyclicality should be included in the specification of productivity equations.(2)

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(1) George Perry took the same position in a recent paper on productivity in the U.S., in which he wrote that he refused "to force the capital stock into the story by constraining it to enter the equations." He also reported that capital was insignificant in his productivity equations, but did not indicate what specification he used. See George L. Perry, "Potential Output and Productivity", Brookings Papers on Economic Activity, 1977:1, pp. 11-60.

(2) It is the case that a good many productivity functions are estimated without any correction for cyclicality in the equations. A recent paper by Michael Denny and Douglas May on the translog production function in Canadian manufacturing provides an example. The parameters of their equations combine secular and cyclical effects, and can thus shed little light on the secular contribution of capital to growth. See J.D. May and M. Denny, "Progrès technique augmentant le produit marginal des facteurs et productivité dans l'industrie manufacturière canadienne", L'Actualité Economique, Vol. 53, No. 3 (Juillet-Septembre 1978), pp. 322-336.

Another interesting example of this problem appears in William Nordhaus' 1972 paper on the productivity slowdown in the U.S. Nordhaus developed measures of capacity utilization for 12 major industry groups and found that productivity movements in these industries were generally pro-cyclical. In measuring the contribution of capital to productivity growth, however, he adopted the assumption that productivity has no cyclical behaviour. His empirical results, which he described as "very discouraging", suggested that capital growth had either no effect upon, or in fact depressed productivity growth. These results are difficult to interpret, however, because of the arbitrary cyclical assumption. See Nordhaus, op. cit., p. 514.

A.3.2 Empirical Analysis and Results

In order to estimate the impact of changes in capital-labour ratio growth rates in the 1970s upon trend productivity growth, a number of calculations are required. It is necessary to estimate both the extent to which trend capital-labour ratio growth rates and trend productivity rates declined, and the relationship between changes in productivity growth and changes in capital intensity. The first step is to calculate the extent to which cyclically-adjusted capital labour ratio growth has declined, industry by industry. This is done through estimating the simple model,

$$\log k_i = \alpha_1 + \alpha_2 \log CU_i + \alpha_3 \log CU_i(-1) + \alpha_4 t + \alpha_5 t_{57} + \alpha_6 t_{73}, \qquad (7)$$

where k_i = the capital-labour ratio in industry i,
CU_i = a measure of the extent of capacity utilization in industry i,
t = a time trend beginning in 1947,
t_{57} = a time trend beginning in 1957, and
t_{73} = a time trend beginning in 1973.

Capacity utilization in industry i, CU_i, is derived as a function of capacity utilization in the entire commercial non-agricultural sector, CU. CU_i is equal to Q_i/QN_i, where Q_i and QN_i are actual output and cyclically-adjusted output, respectively, in industry i. QN_i is calculated as the prediction of the equation

$$\log Q_i = \beta_1 + \beta_2 \log CU + \beta_3 \log CU(-1) + \beta_4 t + \beta_5 t^2, \qquad (8)$$

when CU takes its average value over the estimation period 1947-1978.(1,2)

The trend rate of growth of the capital-labour ratio k_i over the period 1947-1956 is captured by the coefficient of t in equation (1), α_4. There appears to have been a sharp break in the rates of growth of capital-labour ratios in most industries, and in the economy as a whole, in the mid-1950s (see Table 11); a time trend starting in 1957 is included in the equation to test for existence of a break in the growth rates of the k_i after 1956. The 1957-1972 average annual rate of growth of the k_i estimated from equation (7) is thus $\alpha_4 + \alpha_5$.

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(1) The capacity utilization index CU is computed using the trend through peak method adapted from the Wharton School methodology. The assumption has been made that capacity in the non-agricultural commercial sector grew by 4.5 per cent per year after 1973. This is a rate of growth well below the 5.6-per-cent trend rate of output growth over the period 1967-1973. With the 1973 value of CU set at 100, its 1978 value is 94.8. For comparative purposes, the 1978 values of the Statistics Canada and Bank of Canada capacity utilization indexes for the manufacturing sector (again, with the 1973 values of these indexes set at 100) were 95.3 and 96.6 per cent, respectively.

(2) For a discussion of the rationale for the inclusion of the lagged capacity utilization term in these equations, see p. 61 below.

A final time trend was added to test for a further possible change in the rates of growth of capital-labour ratios in the early 1970s. The trend specified in equation (7) starts in 1973; the 1973-1978 average annual rate of growth of the k_i is thus $\alpha_4 + \alpha_5 + \alpha_6$. However, the examination of the movement of residuals from an estimated aggregate productivity regression suggested that a break in the trend rate of growth of productivity may have occurred as early as 1971. Another set of equations similar to equation (7), but with the final time trend specified as t_{71}, was thus also estimated.

Table 21 provides estimates of the extent to which cyclically-adjusted capital-labour ratio percentage growth rates are estimated to have declined from 1957-1972 to 1973-1978 and, using the second specification of the final time trend, from 1957-1970 to 1971-1978. In qualitative terms, the results are similar whether the break in trends is postulated to have occurred in 1973 or in 1971.

Table 21

Estimated Average Annual Changes in the Cyclically-Adjusted Percentage Growth Rates of Capital-Labour Ratios, Selected Industries, Canada, 1957-1972 to 1973-1978 and 1957-1970 to 1971-1978

	1957-1972 to 1973-1978	1957-1970 to 1971-1978
Agriculture, forestry, fishing and trapping	*(1)	*
Mines, quarries and oil wells	-4.8	-3.4
Manufacturing	-1.4	-1.1
Construction	*	*
Electric power and gas distribution	-1.8	-1.3
Transportation, storage and communication	-1.6	-1.5
Trade	-1.3	-1.3
Finance, insurance and real estate	*	-1.3
Commercial community, business and personal services	4.9	5.5
Commercial sector total	-0.7	-0.7

(1) An asterisk denotes that an estimated change in a growth rate is not significantly different from zero.
Source: Davenport, op. cit., and Long Range and Structural Analysis Division, Department of Finance.

The second step which is required in the calculations is the estimation of the extent to which cyclically-adjusted rates of productivity growth have declined in the 1970s. Cyclically-adjusted productivity growth rates were estimated using an equation in which productivity is the dependent variable, and whose right-hand side is identical to the right-hand side of equation (7) above. Table 22 provides estimates of the extent to which trend productivity growth rates are estimated to have declined between the periods 1957-1972 and 1973-1978, and 1957-1970 and 1971-1978. Results are provided only for those major industry groups in which output measurement is assessed as being good, or from fair to good, in quality (see Tables 5 and 6).

Table 22

Estimated Average Annual Changes in Cyclically-Adjusted Productivity Percentage Growth Rates, Selected Industries, Canada, 1957-1972 to 1973-1978 and 1957-1970 to 1971-1978

	1957-1972 to 1973-1978	1957-1970 to 1971-1978
Agriculture, forestry, fishing and trapping	*(1)	*
Mines, quarries and oil wells	-7.4	-5.9
Manufacturing	-1.4	-1.1
Electric power and gas distribution	-3.2	-2.7
Transportation, storage and communication	-2.1	-1.7
Trade	*	*

(1) An asterisk denotes that an estimated change in a growth rate is not significantly different from zero.

Source: Davenport, op. cit., and Long Range and Structural Analysis Division, Department of Finance.

Third, it is necessary to estimate the relationship between productivity growth and changes in capital intensity. In light of the considerations reviewed in the first part of this appendix, this has been done through estimating an unconstrained productivity equation in which a cyclical correction is included. The estimated equation is:

$$\log q_i = \delta_1 + \delta_2 \log CU_i + \delta_3 \log CU_i\,(-1) + \delta_4 \log k_i^* + \delta_5 t \qquad (9)$$

where q_i = the level of labour productivity in industry i,

CU_i = the degree of capacity utilization in industry i, as before,

k_i^* = a three-year moving average of the capital-labour ratio in industry i, equal to $(k_i + k_i\,(-1) + k_i\,(-2))/3$, and

t = a time trend beginning in 1947.

This equation is based upon a Cobb-Douglas production function with disembodied technical change, with the capacity utilization variables CU_i and $CU_i(-1)$ added to attempt to account for cyclical movements in the dependent variable, output per person employed. The inclusion of the lagged capacity utilization term in the equation reflects the expectation that productivity is a positive function of both the degree of capacity utilization and changes in the degree of capacity utilization.(1)

The capital-labour ratio k_i has been smoothed by averaging it over three years, in order to reduce its cyclicality. In addition, the averaging has the effect of relating productivity to an average value of the capital stock over three years. This is desirable, since much investment is lumpy, and there can be a considerable lag between the time that new capital is recorded as investment in the national accounts, and when it is effectively used to produce output.(2)

Equation (9) reflects the kind of specification used by Nordhaus and Perry, in which productivity is regressed against a previously estimated measure of capacity utilization.(3) A different method of cyclical correction has been used by Clark, who began by regressing man-hours on a weighted average of current and past output, and time.(4) This first regression is used to define cyclically-adjusted productivity, which is then regressed on time and cyclically-adjusted capital per person employed. The cyclical correction of capital per employee, however, is based upon a regression of changes in hours upon changes in the Federal Reserve Board capacity utilization index.

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(1) On a priori grounds, expectations for the signs and the relative magnitudes of the coefficients of CU_i and $CU_i\,(-1)$ are that $\delta_2 > 0$, $\delta_3 < 0$, $\delta_2 + \delta_3 > 0$. If the cyclical behaviour of productivity is as postulated, the relevant portion of the equation could be rewritten as $\theta_2 \log CU_i + \theta_3 (\log CU_i - \log CU_i\,(-1))$, and the expectation would be that $\theta_2 > 0$ and $\theta_3 > 0$. But, referring back to the equation, $\theta_2 + \theta_3 = \delta_2$, and $\theta_3 = -\delta_3$. The expectations that $\delta_2 > 0$, $\delta_3 < 0$ and $\delta_2 + \delta_3 > 0$ follow.

(2) The use of end-year capital stock data in the regressions means that, for example, the flow of output during the calendar year 1978 is related by (9) to the stocks of capital on December 31 of 1976, 1977 and 1978.

(3) Nordhaus op. cit., and Perry, "Potential Output and Productivity", op. cit.

(4) Clark, op. cit.

Estimated coefficients and summary statistics for the regressions from equation (9) are provided in Table 23, for those industries in which output estimates are judged to be good, or from fair to good, in quality. For almost all of the industries, initial results indicated a high degree of autocorrelation present in the estimates. The equations were re-estimated using the Cochrane-Orcutt autocorrelation correction method; estimated values of the autocorrelation coefficient are given in the last column of the table.

Table 23

Parameter Estimates and Summary Statistics for Productivity Functions, by Industry, Canada, 1947-1978

	CU_i	$CU_i(-1)$	k_i*	100t(1)	$\bar{R}^2$	d.w.	rho
Agriculture, forestry fishing and trapping(2)	1.09 (25.1)	*(3)	.57 (7.9)	1.14 (2.8)	.99	1.72	.41
Mines, quarries and oil wells	.48 (5.6)	-.23 (2.7)	.70 (4.8)	*	.92	1.08	.97
Manufacturing	.52 (10.0)	-.12 (2.1)	.52 (4.3)	1.83 (4.3)	.99	1.67	.83
Electric power and gas distribution	1.24 (10.9)	-.30 (2.8)	1.16 (5.1)	*	.97	1.49	.91
Transportation, storage and communication	.58 (6.1)	*	.79 (5.0)	2.42 (7.9)	.98	2.06	.82
Trade	.74 (13.0)	-.30 (4.9)	*	1.75 (36.6)	.99	1.92	.24

(1) The estimated coefficients of the time trends have been multiplied by 100, so that they represent average annual percentage growth rates.
(2) Figures in parentheses underneath coefficient estimates are t-values.
(3) An asterisk denotes that an estimated parameter is not statistically significant.

Source: Davenport, op. cit., and the Long Range and Structural Analysis Division, Department of Finance.

The regression results confirm the general expectation that productivity growth is significantly influenced by movements in the capital-labour ratio. The estimated coefficients of the capital-labour ratio variable are positive, with a high level of statistical significance, for all industries except trade. The relatively large size of these coefficients indicates that growth in the capital intensity of production appears to be a more important contributor to productivity growth than is suggested, for example, in growth accounting literature. For all industries, the contemporaneous capacity utilization variable CU_i is positively related to productivity, as expected, and is statistically significant. The

lagged utilization term CU_i (-1) is correctly signed and is statistically significant in the case of four of the six major industry regressions. Positive trend rates of growth of productivity are estimated for agriculture and other primary, manufacturing, transportation, storage and communication, and trade; no significant trend productivity growth rate over the period since 1947 is estimated for mines, quarries and oil wells and electric power and gas distribution.(1)

Equation (9) was also estimated for the aggregate commercial sector of the Canadian economy. The estimated coefficient on the capital-labour ratio in this regression was .82.(2) This is a coefficient value similar to the value of .70 obtained by Clark in his analysis of the relationship between productivity growth and the gross capital-labour ratio in the private non-farm sector of the U.S. economy. Although Clark's estimated capital-labour ratio coefficients declined when the net capital stock was substituted for the gross capital stock in his regression (see above, page 37, footnote 1), they remained well above the 20-per-cent profit share in income. Clark, like Frankel, has interpreted the difference between his estimated capital-labour ratio coefficients and the profit share of income as evidence that technical progress depends upon the capital-labour ratio as well as on "time".(3)

A final point with respect to these regressions relates to the functional form of the estimating equation. Despite the results summarized in Table 23, and even if the aggregate marginal productivity assumptions did not hold, it would of course be possible for the actual relationship among output, capital and labour to be of the CES form. The amount and direction of bias in the coefficient of the capital-labour ratio would then be of interest.

The greatest degree of slowing in capital intensity growth has occurred in the mining industry: the decline in the average annual growth rate is estimated to have been 3.4 percentage points between 1957-1972 and 1973-1978 or 4.8 percentage points between 1957-1970 and 1971-1978 (see Table 21). R.R. Nelson has shown that for this magnitude of change in the capital-labour ratio, the contribution of capital to growth is highly insensitive to the choice of the elasticity of substitution.(4) Moreover, if factor-augmenting technical change is allowed for, the direction of bias in the coefficient is not unambiguous. If the elasticity of substitution is less than unity, then with unchanged rates of

(1) An additional time trend beginning in 1974 was used in the mining industry regression, in order to specifically allow for the changed situation in the crude petroleum and natural gas industry. The estimated 1974-1978 time trend is strongly negative.
(2) Davenport, op. cit., p. 32.
(3) Clark, op. cit., p. 971.
(4) R.R. Nelson, "The CES Production Function and Economic Growth Projections", Review of Economics and Statistics, Vol. 47, No. 3 (August 1965), pp. 326-328.

factor-augmenting technical change, a slowdown in the growth of the capital-labour ratio should raise the capital elasticity of output.(1) The assumption of a constant capital-labour ratio coefficient might therefore lead to an underestimate of the impact of changes in the capital-labour ratios in the 1970s.

Table 24, finally, combines the various results reported in this appendix into estimates by industry of the extent to which estimated declines in trend capital-labour ratio growth rates have reduced trend productivity growth rates in the 1970s. Estimates for each of the periods 1973-1978 and 1971-1978 are provided. The calculation of these estimates can be illustrated with reference to the transportation, storage and communication (TSC) industry for the period 1973-1978. Between 1957-1972 and 1973-1978, the growth rates of the capital-labour ratio and productivity in TSC were estimated to have slowed by 1.6 and 2.1 percentage points, respectively (Tables 21 and 22). The estimated capital intensity coefficient for this industry is .79 (Table 23). The portion of the slowdown in 1973-1978 productivity growth in TSC accounted for by the slowdown in capital intensity growth is thus calculated as (.79 x 1.6)/2.1, or 60 per cent.

Table 24

Estimated Proportion of Change in Trend Productivity Growth Rates Accounted for by Changes in Trend Capital-Labour Ratio Growth Rates, Selected Industries, Canada, 1973-1978 and 1971-1978

	1973-1978	1971-1978
	per cent	
Agriculture, forestry, fishing and trapping	0	0
Mines, quarries, oil wells	45	40
Manufacturing	52	52
Electric power and gas distribution	65	56
Transportation, storage and communication	60	70
Trade	0	0

Source: Davenport, op. cit.; and Long Range and Structural Analysis Division, Department of Finance.

(1) With factor-augmenting technical change, the elasticity depends upon the capital-labour ratio in efficiency units; cf. E. Burmeister and A.R. Dobell, Mathematical Theories of Economic Growth, (MacMillan and Co., New York, 1970), Chapter 3.